# NATURE

No. 4215 SATURDAY, AUGUST 12, 1950 Vol. 166


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*Editorial and Publishing Offices of "NATURE"*
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831
Telegrams: Phusis Lesquare London
*Advertisements only should be addressed to:*
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone Number: Temple Bar 1942
The annual subscription rate is £4 10 0, payable in advance, inland or Abroad.


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## FREEDOM OF INFORMATION

PROF. NIELS BOHR'S "Open Letter" to the United Nations*, pleading that every initiative from any side towards the removal of obstacles to free mutual information and intercourse would be of the greatest importance in breaking the present deadlock and encouraging others to take steps in the same direction, will be read with much respect even by those who are most dubious as to whether he really faces the arguments on the other side. That respect is enhanced by the quotations from memoranda submitted by him to President Roosevelt in July 1944 and in March 1945, directing attention to dangers which would confront us if effective control measures were not established to provide a guarantee of common security, so as to permit such concessions regarding exchange of information and openness about industrial efforts, including military preparations, as would prevent a competition prepared in secrecy. The frankness and sincerity of the quotations speak for themselves, and Prof. Bohr need have no fears that he has failed to convey a vivid impression of the fervent hopes of those early days of the atomic energy project, that the progress of science might initiate a new era of harmonious co-operation between nations, or of the anxieties lest any opportunity to promote such a development be forfeited.

There will be almost universal agreement among the scientific men of the Western world with much that Prof. Bohr has written in this pamphlet. Few, if any, will deny that for the rapid development of science and, in particular, for the adventurous exploration of the properties and structure of the atom, international co-operation of an unprecedented extent and intensity has been of decisive importance. The fruitfulness of the exchange of experience and ideas between scientific workers from all parts of the world was a great source of encouragement to every participant, and did indeed strengthen the hope that an ever closer contact between nations would enable them to work together on the progress of civilization in all its aspects.

Not only is there in Great Britain, as in the United States, universal appreciation among men of science, at least, of the importance for the advancement of science of free intercourse across national frontiers, but also even the most casual reader of the scientific and technical Press can scarcely fail to be aware of the impatience of the scientific community in both countries at any restraints on freedom of discussion and publication of scientific and technical information which are not plainly justifiable in the public interest. The creation of new barriers, restricting the free flow of information between countries, has not been accepted without protest, and, where accepted, is manifestly viewed with anxiety. Nevertheless, Prof. Bohr's view that the continued secrecy and restrictions deemed necessary for security have themselves split the world community of science into separate camps will not be generally accepted.

* Open Letter to the United Nations, June 9th, 1950. By Niels Bohr. Pp. 13. (Copenhagen: J. H. Schultz Forlag; London: Cambridge University Press.) 3*d*.

It may be true that a more constructive approach to the problem of the control of atomic energy requires an atmosphere of greater confidence; but Prof. Bohr does not mention the limited and spasmodic participation of Eastern European nations in international scientific conferences. The exchange and interchange of information must be at least bilateral and not unilateral if the advancement of science is to be furthered. That much indeed Prof. Bohr appears to recognize from his suggestion to the Secretary of State in a memorandum, dated May 17, 1948, submitted as a basis for conversations in Washington, that careful consideration should be given to the consequences which might ensue from an offer, extended at a well-timed occasion, of immediate measures towards openness on a mutual basis.

Prof. Bohr's reference to timing is as important as his emphasis on reciprocity. Without such qualification, the measures he suggests, granting in some suitable manner access to information of any kind desired about conditions and developments in the various countries, which would thereby allow the partners to form a proper judgment of the actual situation confronting them, could scarcely be considered seriously. Even with these qualifications, an initiative along such lines lies beyond the scope of conventional diplomatic caution, even when it is considered that acceptance of the proposals might effect a radical improvement of world affairs, with entirely new opportunities for co-operation and far-reaching agreement on effective measures to eliminate common dangers. Except by implication, Prof. Bohr does not address this specific proposal to the United Nations. He appears to dismiss the suggestion that has been canvassed that humanity should renounce for a period of years the prospect of utilizing atomic energy for peaceful purposes until the conditions for the effective control of its possible military use have been established. He pleads for an unprejudiced attitude towards all questions of international relations, and insists that proper appreciation of the duties and responsibilities implied in world citizenship is more necessary than ever before.

Within any community, the citizens can only co-operate for their common welfare on the basis of public knowledge of general conditions in the country. Similarly, real co-operation between the nations of the world on problems of common concern presupposes free access to all information of importance for their relations. If nations are to benefit from the experience of others and avoid mutual misunderstanding, free access to information and unhampered opportunity for exchange of ideas is essential, and the benefits of such common enlightenment and the reduction of tension have to be weighed against any effect on national ideals or interests. No impartial or unprejudiced observer, however, can ignore the plain facts that, in the U.S.S.R. and her satellites, access to such information is rigorously denied, and further, as the statement made on October 25, 1949, by the delegates of Canada, China, France, the United States and the United Kingdom shows, of the six sponsoring powers of the United Nations Atomic Energy Commission, only the U.S.S.R. refuses to consider measures of control or international co-operation which may interfere with the exercise of its sovereignty.

It is true that, as Prof. Bohr observes, abolition of barriers implies greater changes in administrative practices in countries where new social structures are being built up in seclusion than in countries with long traditions in government organisation and international contacts. It is in the latter countries, moreover, that the community at large as well as scientific men themselves has come nearest to recognizing that knowledge is in itself the basis for civilization and that modern warfare has disrupted the communications and the intercourse which men of science and scholars generally had been accustomed to enjoy in Western Europe for at least five centuries. That, of course, is the reason why such concern has been expressed in those countries as to the effects of continued secrecy not only in atomic development but also in other fields.

To recognize those dangers is not, however, necessarily to agree that the present atomic deadlock is the cause rather than the consequence of bad relations between eastern Europe and the West over the past five years. We have little or no idea at present how much new knowledge in nuclear physics or in any other branch of fundamental science the Russians could, if they wished, contribute to the common fund. Nor can any real hope be held out of that position improving until the Russian scientific workers generally are as free as those in other countries employed on non-secret work to open their laboratories to the world, exchange periodicals and carry on their investigations at least in friendly disagreement. To the questions here raised Prof. Bohr offers no answer, nor does he in this "Letter" indicate any fresh approach or substantial reasons for believing that there is any greater disposition on the Russian side to the frankness and openness on which, as he recognizes, co-operation really depends.

Prof. Bohr's "Letter" does not imply that secrecy in regard to atomic energy is inconsistent with the fundamental condition of a democracy, whether within a nation or in a community of nations, that the people should be given the essential information by which to set their course; though it may easily be twisted to give that impression. Further, it does not emphasize that there is, both among scientific men and among the British and American people generally, a fairly widespread realization that the true strength of the Western democracies lies not in the possession of atomic weapons but in efforts to promote a better and more prosperous life for men everywhere, and to keep alive all over the world, as Mr. D. E. Lilienthal remarked in this connexion last October, the spirit of free and independent men. Prof. Bohr's "Letter" is an appeal to the conscience of the United Nations; but it does less than justice to the lively consciousness of the moral and spiritual factors in the problem which has been evident during the past five years not only in the United States and Great Britain but also in much of Western Europe. Nevertheless, it may at least provoke some more

realistic thinking in regard to the secrecy problem in the Western world, and put an end to some of the absurdities which have been hampering scientific discussion in the field of nuclear physics and which may well have contributed to misunderstandings or to swelling the suspicions which the U.S.S.R. seem only too ready to entertain.

## CHARGES MOVING IN AND NEAR THE SUN

### Cosmical Electrodynamics

By Prof. H. Alfvén. (International Series of Monographs on Physics.) Pp. viii+238. (Oxford: Clarendon Press; London: Oxford University Press, 1950.) 25*s*. net.

IT has truly been said that this is the electromagnetic era in astrophysics. Earlier, electromagnetic theories of cosmic phenomena rested on a somewhat insecure foundation; now, however, observations of stellar and solar magnetic fields, of the motions of gas near sunspots, and of solar and galactic radio noise have made it clear that electromagnetic phenomena cannot be disregarded. A large part of F. Hoyle's book, "Some Recent Researches in Solar Physics" (see *Nature*, 165, 377; 1950), was concerned with such phenomena; and now we have a book by Prof. H. Alfvén on related topics.

The structure of Alfvén's book is essentially very simple. A short general survey is followed by three chapters discussing the motion of charged particles in a magnetic field, electric discharges, and the magneto-hydrodynamic waves which Alfvén himself first discovered. The ideas developed in these three chapters are then applied in a further three chapters to solar physics (sunspots, chromospheric and coronal temperatures, prominences, etc.), magnetic storms and auroræ, and cosmic radiation.

The book is theoretical and, save in the chapter on electric discharges, normally concerned with Alfvén's own researches. For example, in discussing the motion of charges in a magnetic field, a brief account only is given of Störmer's work; most of the time is spent explaining a method originated by others, but which Alfvén has greatly developed. This method, which is applicable to particles of moderate energy, represents the motion as a spiralling about the lines of force, together with a drift across these. Alfvén does not concern himself with the details of the spiralling, but with the motion of a "guiding centre" about which the spiralling is supposed instantaneously to be taking place.

The valuable chapter on electric discharges is not the only feature which reminds one that the author is an electrical engineer. He likes to illustrate an argument by introducing the equivalent circuit. When, in the theory of magnetic storms, he finds it difficult to calculate the field of the current systems which he postulates, he uses a scale model to give him the results which he seeks. But his treatment of lines of force in the theory of magneto-hydrodynamic waves is the most typical. Many engineers speak as if they can see and count lines of force; and in Alfvén's theory the lines of force come to life, writhing and dragging a sticky material about with them.

Because of the clarity of the style, and the novelty of the ideas, the book is both entertaining and stimulating. That does not necessarily mean that the ideas are all correct; but they cannot fail to stimulate those who most disagree with them. Personally, I regard magneto-hydrodynamic waves as a valuable new concept; but I do not believe, as Alfvén does, that such waves are the cause of sunspots. Nevertheless, a doubter is hard put to it to explain the correlation which Alfvén finds between the spottedness in one hemisphere in a given sunspot cycle and that in the other hemisphere in the next cycle, a correlation which his theory easily explains. Equally one can have serious doubts about his theory of magnetic storms; but if one rejects it, one must find an alternative explanation of the diurnal variation of the latitude of auroræ, of which he provides strong evidence.

However, two comments must be made. First, nearly all Alfvén's theories postulate a general magnetic field of the sun. Observation has not finally decided whether such a field exists; but if it does, it is probably variable, and often far weaker (at the surface) than Alfvén supposes. Thus the numerical agreements with his theory which he often invokes are far less secure than he suggests. He argues (p. 106) that the success of his theories of sunspots and magnetic storms is strong evidence of the existence of a field of the strength which Hale first found; but an observing astronomer doubtful of the existence of such a field may be tempted to turn the argument round.

Again, Alfvén's theories have met criticisms from several quarters. He does not attempt to gloss over this fact; indeed, he sets out the objections to his discharge theory of solar prominences so forcefully that one almost wonders why he is not convinced by them. Because of the criticisms, however, he has withdrawn from some of the positions confidently maintained in earlier papers, and the gaps thereby left have not been filled. Consequently his arguments too often are vague where they should most be clear. For example, it is noteworthy that in his theory of sunspots he now gives no complete explanation of the darkness of a spot, and his explanation of the generation of a magnetic field above the surface is only sketched and becomes progressively more difficult to grasp the more one tries to enter into details.

One may, perhaps, summarize one's impressions of the book in a sentence from the preface: "The scope of this book is more to put the problems than to solve them". Prof. Alfvén has put many problems, and those reading the book will be made furiously to think. But I do not think that they will be satisfied to leave the solutions just as he has left them.

T. G. Cowling

## INTROGRESSIVE HYBRIDIZATION

### Introgressive Hybridization

By Edgar Anderson. (Wiley Biological Research Series.) Pp. ix+109. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1949.) 18*s*. net.

IN this small book of a little more than a hundred pages, Prof. Edgar Anderson deals from a rather unusual angle with the quantitative and genetical aspects of the impact of one species upon another through the intermediary of a hybrid swarm. The quantitative methods which are described may find useful applications in population genetics, ecology,

the study of hybrid swarms, and, it is claimed, in practical plant and animal breeding.

One of the commonest features of hybrid swarms is the tendency which they have to merge with either or both of the parent species by repeated back-crossing. The process by which genes pass from one species to another was named "introgressive hybridization" by Anderson and Hubricht in 1938, though the possible importance of the gradual infiltration of the germ plasm of one species into another was suggested by Ostenfeld in 1927. It is somewhat unfortunate that the author makes no attempt to deal adequately with the literature on introgression. For its evolutionary and taxonomic significance the reader is referred to other sources. Yet from the title of the book it might be expected that the subject would be discussed from the broader point of view of its significance to the general biologist interested in evolutionary mechanisms, and in this way appeal to a much wider audience.

It is stated that the quantitative methods described are useful in practical plant breeding. It is also claimed that, by using these quantitative methods upon a hybrid population, an exact description of a parental species component can be made without ever having seen it.

The soundness of this claim must be judged from the wider aspect of what happens when single genes are transferred from one species to another by repeated back-crossing. More work has probably been done on interspecific gene transference in *Gossypium* (cotton) than in any other genus. Here it seems that a recessive gene can pass from one species to another and be incorporated without much visible effect, except that resulting from interaction with a new set of species modifiers. Dominant genes, however, are usually accompanied by a series of modifiers which enhance their effects. When these dominants pass to a species with the corresponding recessive alleles, they often become so denuded of their modifiers as to produce almost negligible effects. In such cases it would not be possible to compile a taxonomic description of the non-recurrent species, and the view that it is generally possible to do this must be held to be genetically naïve.

But this short (and expensive) book is a mine of valuable ideas—valuable as much for their novelty as for their presentation by a biologist who has always succeeded in stimulating his readers and making them think.

S. C. HARLAND

## HYDRODYNAMICS, CLASSICAL BUT MODERN

### Theoretical Hydrodynamics

By Prof. L. M. Milne-Thomson. Second edition. Pp. xxiii+600+4 plates. (London: Macmillan and Co., Ltd., 1949.) 60*s*. net.

THE first edition of this well-known book appeared in 1938 and was characterized by the consistent use of the vector notation and a carefully lucid exposition. The author explains in the preface that the book is founded upon lectures given at the Royal Naval College, Greenwich, to junior members of the Royal Corps of Naval Constructors, and that his object is to give a thorough, clear and methodical introductory exposition of the mathematical theory of fluid motion, such as may be useful in applications to hydrodynamics and aerodynamics. It may be said at once that the author has succeeded in his aim, subject, however, to certain important limitations in the scope of the book. Thus, although one chapter is devoted to the discussion of the motion of viscous fluids, the theory of the boundary layer is dismissed in three pages, and the author states: "The theory of the boundary layer serves as a useful guide to experimental work and gives a qualitative description of viscous motion near a boundary, but its applications have so far been of a tentative and empirical character". I cannot accept this as an unbiased assessment of the present status of the boundary layer theory, and would record the widely held opinion that the study of the boundary layer is of fundamental importance for the advancement of the dynamics of real fluids.

The second edition now under review retains the characteristics of the first, but contains a considerable amount of new material, much of it relating to recent research. A new chapter entitled "Subsonic and Supersonic Flow" gives an elegant and very concise account of the motion of inviscid compressible fluids, typically perfect gases. This includes an account of the hodograph method, with Chaplygin's equation and the applications of the hypergeometric function, and of the method of characteristics. Novelties not concerned with compressible fluids include the 'circle theorem', due to the author himself, which establishes a very simple general formula for the interference produced by a fixed circular boundary in two-dimensional flow; by means of the theorem the potential of the image system can be written down at sight. The corresponding theorem for a fixed spherical boundary is also given; this is due to Weiss and is rather less simple. A recently introduced conception of importance is the vector circulation, which plays a part in three-dimensional flow similar to that of the scalar circulation in two-dimensional flow.

We may sum up by saying that the book gives a lucid account of classical hydrodynamics, including the results of much recent research. Its value as a college text-book is enhanced by the inclusion of 558 examples, drawn largely from university examination papers. The printing is excellent; but the price is regrettably, if justifiably, high.

W. J. DUNCAN

## DOCUMENTATION OF THE NITROGEN COMPOUNDS OF NAPHTHALENE

### Elsevier's Encyclopædia of Organic Chemistry

Edited by F. Radt. Series 3: Carboisocyclic Condensed Compounds. Vol. 12*B*: Naphthalene, A. Compounds containing One Naphthalene Nucleus—Nitrogen Compounds. Pp. xxxvi+345–1052+Ind. 75. (New York and Amsterdam: Elsevier Publishing Co., Inc.; London: Cleaver-Hume Press, Ltd., 1949.) £18 to subscribers of the whole work.

THIS second part of Vol. 12*B* consists of 708 pages of text and 75 pages of indexes. The first part has already been reviewed in these columns (see *Nature*, **163**, 822; 1949; and, for a general description of the whole project, see *Nature*, **161**, 415; 1948). The nitrogen derivatives of naphthalene which are treated within the compass of this second part include the various nitro compounds of naphthalene

and its homologues, and the corresponding compounds in the series of hydronaphthalenes. Polynitro compounds appear in impressive array, and the 230 pages taken up by α- and β-naphthylamines and their derivatives contain a wealth of attractively presented information about these important compounds. The other classes of compounds dealt with include the halogen derivatives of nitronaphthalenes and naphthylamines, polyaminonaphthalenes, nitroamino compounds, and homologues of all these classes together with corresponding hydronaphthalene derivatives. There are sections dealing with hydrazine derivatives, diazo compounds, azo compounds (including large numbers of azo dyes), azoxy compounds, azides and triazenes.

Classes of compounds which have yet to be treated before Vol. 12*B* is complete include the naphthalene- and naphthylamine-sulphonic acids, the naphthols and aminonaphthols, and their sulphonic acids. Even then, the carboisocyclic condensed compounds will not have been fully covered, and this is the only section of the Encyclopædia of which parts have been issued so far. All this serves to illustrate the magnitude of the task which the publishers and editor have undertaken. Each new part which appears increases the usefulness of the work, but a speeding up is essential if the original purpose is to be achieved.

The volume under review fully maintains the high standard of the earlier issues. It is excellently produced, and the inclusion of references to biological properties, as well as to extensive physical data, is again to be welcomed, especially in regard to the considerable series of bases related to the hydronaphthalenes. Other pleasing features are the tables of data relating to various series of derivatives, such as molecular compounds, salts, acyl derivatives, urethanes, etc. These tables facilitate rapid reference and also give helpful pictures of the extent of the fields covered. The comments and suggestions of the editor directing attention to doubtful structures, inconsistencies in the literature, etc., again illustrate the skill and thoroughness with which the compilation and classification have been carried out. Another useful feature is the formulation (on p. 651) of twenty-four heterocyclic structures which are mentioned in the text as being obtainable from the naphthylamines or their derivatives.

The present volume is based on literature published up to the end of 1944, and there are a few references to publications of 1945–49. Like its predecessors, this volume will be found in all adequate chemical libraries, and it will be consulted frequently by those interested in the chemistry of naphthalene derivatives.

J. W. Cook

## STATISTICAL SAMPLING

### Sampling Methods for Censuses and Surveys

By Dr. Frank Yates. Pp. xiv+318. (London: Charles Griffin and Co., Ltd., 1949.) 24*s*. net.

THE United Nations Sub-Commission on Statistical Sampling held its first session at Lake Success in September 1947 and asked on that occasion for a manual to be prepared to assist in the execution of the projected 1950 World Censuses of Agriculture and Population. This request has been handsomely met by the present publication under the authorship of Dr. Frank Yates, head of the Department of Statistics, Rothamsted Experimental Station, himself a member of the Sub-Commission. Dr. Yates took the opportunity to write a general book which is certainly a notable addition to the growing literature on the theory and practice of statistical methods. Quite enough is now known of the particular methods which are suitable for censuses and surveys of all sorts to make a sizable publication in itself, and the book is of particular value in that it makes available in one work of reference what could previously have been gleaned only by painstaking research over a large number of scattered publications.

Before the Second World War it could perhaps have been broadly said that the very lively development of the theory of statistics in relation to the biological sciences, and in particular to agriculture, did not have much in the way of impact on the economic and official statisticians who did much of the census and survey work. The study of sampling in agricultural research received an impetus from the newer experimental designs, due to Prof. R. A. Fisher, which exploited to the full the known methods of mathematical statistics. When for various reasons part only of the experimental produce could be gathered in, an adaptation of the technique produced satisfactory results by enabling the sampling errors to be isolated and measured. It is scarcely surprising, therefore, that this particular aspect of the modern refinements of the statistical method should have been singled out for very wide application, since the sampling method has come to be a potent tool in conducting censuses and surveys over a wide domain. In this way the mathematician and the official census officer have met.

It may surprise the casual reader to find that so much has to be thought about in relation to the problem, and that there are so many facets to this particular jewel. The book has eight chapters, of which the first three deal with the sample itself: first, the place of sampling in census work, in which opportunity is taken to describe the sampling process and to define sampling errors; then, the requirements of a good sample, with emphasis on bias and its avoidance; and lastly, the structure of various types of sample, cataloguing many methods. Two chapters follow on the problems of a survey, one dealing with those that arise in planning it, and the other concerned with its execution and analysis. The technical aspects increase in volume towards the end; two chapters deal with estimation, first of the 'population' values and then of the sampling error; and finally there is a full discussion of the question of 'efficiency' in its statistical meaning.

A book like this cannot in the nature of things be easy reading right through; but it is at any rate broadly non-mathematical, even where it deals with mathematical concepts. This does not mean that there are not plenty of formulæ, but they are not proved, and there is a profusion of arithmetical illustration. The reader who has a general acquaintance with the methods of statistics should be able to follow the author quite well. He will be tempted by the lucid accounts of the practical aspects of sampling procedure to continue reading, when he will find that in spite of himself he is learning quite a lot about the statistical techniques. It is not everyone who will want to master these thoroughly; but they are there for the expert, and it is a good idea that the planner, even if he is not himself the analyst, should see the sound character of the basic methods which are essential to his study.

J. Wishart

## The Libraries of London

Seventeen Lectures delivered at the University of London School of Librarianship in April 1948. Edited with an Introduction by Raymond Irwin. Pp. iv+234. (London: Library Association, 1949.) 13*s*. 6*d*.; to Members of the Association, 10*s*. 6*d*.

THE account in this book of the Guildhall Library is the first real description of that Library that I have seen, and it is contained, moreover, in a book that, apart from a certain bias towards the librarian's rather than the user's point of view, is well suited to the needs of the undergraduate and student. Well printed and produced, as is customary with books bearing the imprimatur of the Library Association, this volume nevertheless carries a little too much the defects of an unco-ordinated series of lectures. They are not all of equal merit; but some, notably those on the British Museum, Science Museum Library, Patent Office Library, University of London Libraries, British Library of Political and Economic Science, London Library and the National Central Library, could not easily have been better done for the purpose.

The editing, however, has not given sufficient cohesion to the book, and there is marked lack of balance and proportion. While, for example, thirty-seven pages are given to the Public Record Office and its work, in a text of 218 pages government departmental libraries are dismissed in ten, the medical libraries in eleven and the law libraries in fourteen. Interesting as is the account of the methods of work in the Public Record Office, it is purchased too dearly at the virtual exclusion of any account of the libraries of science and technology, other than those at the Patent Office, the British Museum (Natural History) and the Science Museum; that of the Chemical Society is not even mentioned, and there are the briefest references to those of the other learned or royal societies in the field of science (and these are sometimes only in the bibliography). Similarly in theology, there is no reference to Dr. Williams's library and other important theological libraries.

This balance should be redressed in subsequent editions if the book is to be commended without reservation to students of librarianship or to the London undergraduate generally. R. BRIGHTMAN

## World Philosophy

A Search for Synthesis. By Prof. Oliver L. Reiser. Pp. ix+127. (Pittsburgh, Pa.: University of Pittsburgh Press, 1948.) 2.50 dollars.

ALTHOUGH this book was no doubt written in all seriousness and deadly earnest, yet it leaves one with the impression of being intellectually naïve. Briefly, the author's thesis is that this is one world, and it now requires one world culture; only on the basis of a common world view can the peoples of the world come together in peace and co-operative harmony. He believes that the only possible basis for such a synthesis is scientific humanism, and the United Nations Educational, Scientific and Cultural Organisation must have a philosophy; cultural pluralism resists world unification.

Of course, he agrees that scientific humanism must take up a positive and understanding attitude towards æsthetic and religious experience. It "must be sensitive not only to the pulse of America but to the heartthrob of the world". Of course again, religion in general, and all the particular religions, will have to alter their attitudes radically in order to fit themselves into the new world religion of Unesco and science; but the author betrays no consciousness of anticipating any acute difficulties in the working out of these essential re-adjustments.

J. V. LANGMEAD CASSERLEY

## Annual Reports on the Progress of Chemistry for 1948

Vol. 45. Pp. 379. (London: Chemical Society, 1949.) 25*s*.

THE new volume of these reports maintains the high standard of the work. Among the topics dealt with are the chemical action of ionizing radiations, the structure of aqueous solutions of soap-like substances, chemical kinetics, terpenes, colchicine and related compounds, the functions of small molecules in biosynthesis, chromatography, insulin, chemotherapeutic approaches to the tuberculosis problem, and analytical chemistry. The section on inorganic chemistry reverts to the previous practice of giving a review of the whole subject, which seems much more useful and interesting than the arbitrary selection of one or two topics only for detailed treatment.

## A Gardener's Log

By Edna Walling. Pp. xi+220+25 plates. (Melbourne and London: Oxford University Press, 1948.) 15*s*.

EDNA WALLING, who has already written two earlier books on horticulture in Australia, is clearly a true lover of gardens and gardening, and in the present volume she manages successfully to convey her enthusiasm to her readers. "A Gardener's Log" consists of more or less random notes on her gardening experiences in Australia, reprinted from letters appearing originally in *Australian Home Beautiful* and classified under the headings spring, summer, autumn and winter. Inevitably, such contributions to a magazine are light in tone and substance; but British readers will be particularly interested in the comments made on Australian native plants and their value in gardens, as many of them are little known at present in Great Britain. The illustrations are somewhat disappointing, both the photographs and the rather aimless thumbnail sketches scattered through the text.

J. S. L. GILMOUR

## Patterns of Life

By Alan Dale. Pp. xii+338+8 plates. (London: William Heinemann, Ltd., 1949.) 12*s*. 6*d*. net; School edition, 7*s*. 6*d*.

THE spate of books intended to help those who are mildly interested to a fuller knowledge of natural history seems to be unending. The latest to join the stream is Alan Dale's "Patterns of Life", which is worthy of notice both for its comprehensive treatment of the subject and for its down-to-earth writing. Here, one feels, is a book written by someone who accepts all the difficulties which confront those who are beginning the study of natural history and are anxious not to miss anything on the way in their inquiries. Although less likely to stimulate the layman than works which are more attractively illustrated, Dale's book is almost certain to be used as one containing most of the hints and many of the answers. The author's enthusiasm radiates from his descriptions and could scarcely fail to infect the majority of readers for whom his book is intended.

T. H. H.

# GENETICAL STRUCTURE OF POPULATIONS*

By Prof. SEWALL WRIGHT
University of Chicago

THE genetics of populations has two main supports, one of which traces to Galton. A geneticist cannot read "Natural Inheritance" (1889) without feeling that Galton would have welcomed Mendel's paper if it had come to his attention during his active career, and that he would have seen that it and the statistical approach which he initiated were complementary rather than antithetic. Personally, I wish to testify to the great stimulus that I had in reading "Natural Inheritance" as a student.

## Genetical Composition of Populations

I propose to discuss certain genetic aspects of population structure. The term is used to include such matters as numbers, composition by age and sex, and state of subdivision. The best starting point is the consideration of the situation in a large random-breeding population, in which structure in the last sense is absent.

Gene frequencies and hence genetic variability tend to remain unchanged in such a population, generation after generation, because of the persistence of genes and the symmetry of the Mendelian mechanism. This contrasts with the expected halving of variability in each generation (under blending heredity) which Darwin recognized to be the greatest difficulty in his theory of natural selection. This principle was first expressed in general form in 1908 in independent papers by Hardy and Weinberg.

In the same year, another deduction from Mendelian principles, namely, that self-fertilization should result in random fixation of half the heterozygous loci in each generation, was used by Shull to interpret the loss of vigour and the fixation of diverse combinations of quantitatively varying characters which he found in his selfed lines of maize.

## The Inbreeding Coefficient

Extensive experimental results as well as theory indicate that the consequences of any system of close inbreeding are similar, except that a larger number of generations are necessary to reach a given degree of approach to the limiting condition in which there is complete fixation within each inbred line. Many years ago (1922) I proposed an inbreeding coefficient (or fixation index), $F$, as the measure of this degree of approach under any system of mating that does not involve change in gene frequency in the total population. The amount of heterozygosis relative to that in a random-breeding population with the same gene frequencies is given by $(1-F)$, a quantity which it is often convenient to represent by a single symbol, $P$, the panmictic index. It can be shown that the statistical properties of such a population as a whole, as affected by system of mating, and also those of subdivisions, can be described most simply in terms of these indices.

The coefficient $F$ can be shown, moreover, to be the Galtonian correlation between alleles that are brought together at fertilization under the system of mating in question. This property makes it a very simple matter to calculate its value (for autosomal alleles) under any system of mating (of diploids) by a correlation method (the method of path coefficients). Other coefficients can be obtained similarly for sex-linked alleles and for polysomic loci.

The results in simple regular systems of mating, such as continued mating of brother with sister, continued mating of double first cousins, sib-mating in polyploids, etc., agree with those obtained from consideration of the whole system of recurrence relations among types of matings. This latter mode of approach was that used by Jennings and by Fish in the earliest papers on the subject. Its applicability has been considerably extended by the use of matrix algebra by Bartlett and Haldane. It gives a rather complete account of the history of a population under a simple system of mating, but is still too cumbersome for use in complicated cases. The method of path coefficients is complementary in that it yields the most important property (the coefficient $F$) from any specifiable system, however complicated, even though it does not give as much detail in other respects as the matrix method. It can, for example, be applied to breeds of livestock by proper sampling of individuals and pedigree lines.

In populations with hierarchic structure, adequate description requires a hierarchy of inbreeding coefficients. One may calculate the value of $F$ for individuals relative to local populations, that for local populations relative to more comprehensive populations, that for these, relative to still more comprehensive ones and so on, up to the total population. The panmictic index of individuals relative to the total is equal to the product of the panmictic indices relating each level to the next in the hierarchy.

## Factors of Evolutionary Change

The inbreeding coefficient by itself measures merely the effects of random sampling in alleles which have no appreciable tendency to change in relative frequency in a large total population. Realistic discussion of natural populations requires simultaneous consideration of all processes by which gene frequencies may change. These may be put into three categories according to degree of determinacy. There are, first, those which tend to bring about directed changes according to some definite function of the gene frequencies. These may be classified exhaustively into recurrent mutation, immigration and selection. Collectively, these lead either towards fixation of one allele or to a state of equilibrium between two or more alleles. Second are fluctuations which are indeterminate in direction but determinate in variance. These include fluctuations about the mean value of the coefficients for the steady processes, and fluctuations due to accidents of sampling in the parentage of each generation. These variances tend to be cumulative with respect to the array of possible gene frequencies, and thus to lead toward random fixation. This tendency is, however, balanced by the tendency toward equilibrium due to the steady processes. The resultant is a probability distribution of frequencies of gene frequencies which applies to any one strain in the long run, or to an array of strains subject to the same condition, at any one time. The formula

* Substance of the Galton Lecture delivered at University College, London, on June 14.

is a relatively simple function of the coefficients measuring these two processes. Finally, it makes for clarity of thought to recognize a third category, namely, changes in gene frequency that are best treated as indeterminate in both mean and variance: mutations that occur very rarely in the history of the species, and similarly rare hybridizations, unique selective incidents, etc.

As the inbreeding coefficient by itself describes only the effects of population structure in loci in which there is no change in gene frequency in the total population, it takes account only of internal migration in the first category and of accidents of sampling in the second. The other processes may, however, be considered in conjunction with it.

There are two extreme types of population structure which are mathematically convenient in attempting to make this synthesis. The simplest is the island model, in which the species is subdivided into 'island' populations, largely breeding within themselves but receiving a certain amount of immigration, which may be treated as representative of the whole species.

Of greater importance, however, is the population model in which complete continuity and uniform density are assumed, but isolation by distance is possible because of the restriction of dispersion in each generation to small neighbourhoods. The amount of random differentiation depends primarily on the effective size of the neighbourhood. If sufficiently small, differentiation of neighbourhoods carries with it considerable differentiation of large regions.

Of greatest significance are intermediate conditions in which there is heterogeneity with respect to density and dispersion. The condition for random differentiation may be much less severe than in the preceding case.

## Population Structure in Evolution

In considering the significance of population structure in evolution, we must distinguish two aspects of the process: multiplication of species and transformation. Partial isolation obviously tends toward the splitting off of a new species if the environmental conditions are markedly different. The thesis which is stressed here, however, is that a fine-scaled structure of partial isolation, without marked environmental differences, presents the most favourable condition for transformation as a single species.

The advantages over a panmictic population of comparable total size are of several sorts. In the first place, the subdivided population maintains more alleles at each locus and more at moderately high frequencies. In a panmictic species there is a tendency toward the establishment of one type allele at each locus. Possible favourable mutations at two or more removes (that is, mutations of mutations) have little chance of occurrence. There are, to be sure, ways in which two or more alleles may be kept at subequal frequencies (selective advantage of heterozygotes, or advantage of mere rarity), but these are poor compared with those in a subdivided species. In the latter, different alleles may easily be maintained as the types in different places by selective advantages in relation to different conditions, as already indicated, and up to a certain point this favours adaptability of the species as a whole rather than splitting.

Of more importance for transformation as a whole is local differentiation with respect to genotypes that give adaptation to the same conditions. The best-adapted form in a species is usually one that is close to the average in all quantitatively varying characters. There are certain to be a great many genotypes that are of approximately this same optimal type except for pleiotropic genic effects that are of less selective significance at the time. In a panmictic population one of these genotypes inevitably gets a lead over the others and tends to become fixed. In a subdivided population, local fluctuations in conditions that shift slightly the position of the optimum ensure the predominance of different genotypes of essentially the same phenotype in different places. This may, indeed, be brought about in sufficiently small local populations by the accumulation of sampling accidents without any fluctuations in conditions. This process, moreover, brings about differentiation in all other loci in which there are two or more type or near-type alleles with differences in selective value that are below a certain critical ratio to the reciprocal of the effective local population number. It may be well to note here that the effective population number may be expected to be much less than the apparent one for a variety of reasons.

The kaleidoscopic shiftings in the sets of gene frequencies of neighbourhoods may be expected to lead occasionally to predominance of combinations with selective advantages under the prevailing conditions that are far in excess of that indicated by the sum of the net effects of the components. Control by selection thereupon supersedes control by stochastic processes and immigration. Here we come to the second great advantage of a subdivided population over a panmictic one. Favourable combinations may spread through the species by a selective process that operates on the whole, instead of merely on the separate net effects, of the components.

The conditions for such a spread are more favourable in a continuum with isolation merely by distance than under the island model. In the former, centres in which a favourable combination happens to have appeared increase in population and contribute more than their share of migrants to adjacent regions. Because of the strong correlation in all gene frequencies, these adjacent regions do not need much immigration of this sort to carry them beyond the critical point at which selective increase of the combination becomes autonomous. The combination thus spreads through the species in concentric circles without any appreciable mass displacement of populations. Favourable combinations in other respects may arise at other centres and spread similarly, and the two circles of spread may overlap and cross without much interference. On the other hand, combinations that increase adaptation to the same conditions, but which differ genotypically, interfere, and the superior one ultimately displaces the other unless some aspects of both lead to a combination that is better than either, which thereupon spreads concentrically from its point of origin. With fine-scaled structure, new differentiation may be expected to occur concomitantly with the spreading of combinations.

Any number of genes may contribute to a favourable new combination. Some may play an essential part and others that of minor modifiers. An important case is that of a single major mutation which has the potentiality of great advantage if it can be combined with an array of modifiers that bring its effects into harmonious adjustment with other characters. The importance of homœotic mutations in evolution has been frequently stressed by Goldschmidt. Such

mutations usually have low penetrance, and may thus be carried by a species and diffused through it at appreciable gene frequencies in spite of severe antagonistic selection when manifested in their pristine raw form. There is little chance of reaching adjustment in the face of this selection in a panmictic species. In a finely subdivided one, there is a good chance that somewhere, at some time, a combination of modifiers will be encountered which gives sufficient adjustment to reverse the direction of selection locally and thus create a centre from which the system, homœotic mutation and modifiers, can spread as a unit through the species.

### Ecological Opportunity

It must be recognized that most species are held to such restricted ecological niches by the pressure of other species that only an increase in specialization for this niche is probable even with the most favourable population structure. If, however, a more extensive ecological opportunity is ever presented, a finely divided structure is that which is most favourable for its rapid exploitation. Such an opportunity arises when migrants reach territory in which there are many unoccupied niches in which they can live. It also arises when a permanent change in conditions eliminates many species, but leaves the relatively pre-adapted survivors to take over the vacant niches. Most important of all, perhaps, are the occasional cases in which a specialization turns out to be usable in a hitherto unoccupied way of life or to give a general advantage in many ways of life. The origin of the higher categories seems to have its basis in such ecological opportunities.

### Evolution in General

Organic evolution is not the only sort of evolution in the sense of a process of cumulative change. When a level of intelligence making symbolic speech possible was reached in an anthropoid line, a new evolutionary process emerged, enormously more rapid than organic evolution. The line of persistence and accumulation was that from speaker to listener, and later from writer to reader, instead of the germ line. The principles of Mendelian heredity do not apply to the evolution of cultures. Nevertheless, the general qualitative conclusion would still seem to hold, that this or any other evolutionary process depends on a continually shifting but never obliterated state of balance between factors of persistence and change, and that the most favourable condition for this occurs where there is a finely divided structure in which isolation and cross-communication keep in proper balance.

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## STELLAR MAGNETIC FIELDS

By Dr. H. W. BABCOCK

Mount Wilson and Palomar Observatories

GENERAL magnetic fields have been observed in more than twenty-five of the peculiar stars and spectrum variables of types *A* and early *F*, including *HD* 125248 = *BD* − 18° 3789, $\alpha^2 CVn$, *HD* 10783, *HD* 153882, *HD* 188041, *HR* 710, 78 Vir., β Cr. B, and γ Equ.[1]. In nearly all, the field is found to vary; in the first four stars listed the polarity is reversed periodically. The pronounced variations in intensity of certain lines in some of these stars, not explicable

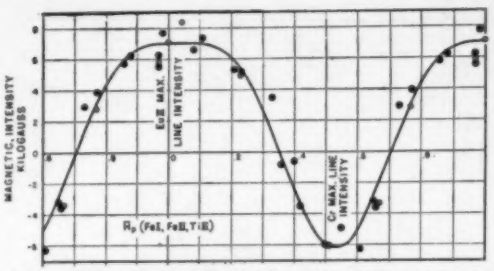


Fig. 1. Polar magnetic field intensity of *HD* 125248 as inferred from Zeeman effect in integrated light. The varying $H_p$, in kilogauss, is plotted against phase in the 9·295-day period according to Deutsch's elements. The maximum positive field occurs when the Eu II lines are at maximum intensity

by ionization theory[2], are only partially accounted for by Zeeman broadening of saturated absorption lines[3]; zonal concentration of elements in the atmosphere as a result of electromagnetic processes must be important.

The most suitable star for detailed study is *HD* 125248 (type *A0p*, mag. 5·7), which was discovered by W. W. Morgan to be a spectrum variable in which lines of Eu II and those of Cr I, II vary through a large range of intensity, but in opposite phase; Fe I, II and most other elements show little change[4]. A. J. Deutsch[5] found the elements of variation to be

$$\text{Eu II max.} = \text{Cr I, II min.} = J.D.\ 2430143{\cdot}07 + 9{\cdot}295\,E. \qquad (1)$$

D. W. N. Stibbs[6] obtained a light curve with amplitude 0·054 mag., maximum light coinciding with maximum intensity of the chromium lines. The reversing magnetic field of this object was discovered at Mount Wilson in 1947[7].

Measurements, made with the assistance of Miss Sylvia Burd, have now been completed on twenty-eight high-dispersion (4·5 A./mm.) spectrograms of *HD* 125248 taken during the past three years with the double circularly polarizing analyser and *coudé* grating spectrograph of the 100-inch telescope. Measured lines of Fe I, II and Ti II, averaging forty per plate, are in good agreement as to field intensity and radial velocity. The polar field strength, $H_p$, computed from the measured Zeeman shifts in integrated light between right- and left-handed spectra on the assumption that line-strength is independent of magnetic latitude[1], is plotted against phase in the 9·295-day period in Fig. 1. The probable error of a determination is about ± 500 gauss. The curve represented by the equation

$$H_p = +\,2{,}000 + 6{,}600\cos\theta - 1{,}600\cos 2\theta \text{ gauss}, \qquad (2)$$

where $\theta = 2\pi\nu_e t$ and $\nu_e = 1{\cdot}25$ microcycles/sec., gives a good approximation to the data; some of the deviations, however, are probably real, indicating either that there are minor features in the true curve or that the amplitude is different in different cycles. The positive maximum of the field occurs at phase 0·03 *P* on Deutsch's elements. Between phases 0·8 and 0·2 the lines of the rare earths, Eu II, Ce II and Gd II, are strong; the indicated $H_p$'s agree roughly with those of the iron group; in both groups there is a suggestion of a sudden increase near phase 0·97. Lines of Cr I, II become strong between phases 0·35 and 0·7; they show a (negative) magnetic intensity consistently stronger than that of the iron lines by some 2 kilogauss or more. The negative extreme is reached near phase 0·61, when Cr I (five lines

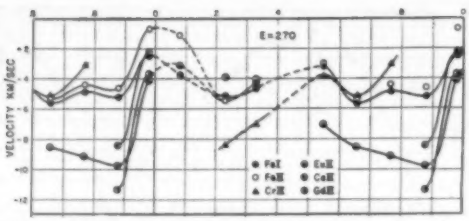


Fig. 2. Radial velocities for different elements plotted against phase

indicates $H_p = -10{,}600 \pm 1{,}400$ gauss and Cr II (thirty-four lines) gives $H_p = -8{,}260 \pm 1{,}160$ gauss.

Radial velocity measurements show anharmonic variations which seem to be coupled with the magnetic changes. Seven plates taken on successive nights show that the velocity amplitude of Fe I is about 3 km./sec., while the curves for Eu II and for Cr II are distinctly different (Fig. 2). The probable error of a point is about $\pm$ 0·4 km./sec. The sudden deceleration near phase 0·97 seems quite significant. Differential velocities between elements are large; for example, between phases 0·6 and 0·97, Eu II shows a nearly uniform outward motion with respect to the iron atoms, through a distance amounting to about 0·6 of the radius of the star, followed by a sudden deceleration.

Near the cross-over points (0·35 and 0·7) peculiar effects were discovered in the profiles of many stellar lines as observed with the polarizer. These effects apparently result from a combination of Doppler and Zeeman effects at a time when the magnetic field is weak and is changing polarity. They are explained on the assumption that the surface of the star is temporarily characterized by two distinct zones of opposite polarity and of slightly different velocity. Apparently the reversal of polarity occurs in a rapid progressive manner over the surface, rather than instantaneously.

The observations of *HD* 125248 suggest that the magnetic dipole axis and the axis of rotation are essentially coincident and fixed nearly in the direction of the line of sight—the star is seen pole-on. The rate of rotation is not directly determinable.

The constant component of the field (2,000 gauss) seems most plausibly to be attributable to a type of regenerative process such as that suggested by E. C. Bullard[8] and by W. Elsasser[9], depending upon axial rotation and convection in the core. This implies that the star rotates at least as rapidly as the average for its type; it also tends to confirm the original premise of these investigations, namely, that strong magnetic fields occur as a result of rotation in early-type stars[1,10]. (For most such stars, rotational broadening of lines, as a result of axial obliquity, precludes a direct test.) According to Deutsch[5], the peculiar *A*-type stars are at least 0·5 mag. brighter than main-sequence stars of corresponding types; this suggests that interior liberation of energy is modified by the magnetic field or by differential rotation.

The principal term of magnetic variation ($+ 6{,}600 \cos\theta$) in *HD* 125248 is best interpreted according to M. Schwarzschild's theory[11], in which there is a coupling between mechanical and magnetic oscillations of the whole star; this is an extension of the theory of magneto-hydrodynamic waves put forward by H. Alfvén[12]. The *odd* mode of oscillation in Schwarzschild's solution seems to prevail; in it there is an oscillating magnetic dipole coupled with mechanical oscillations symmetrical about the equatorial plane. Material near the poles moves radially inward while the star expands at the equator. A half-cycle later the motions are reversed.

An alternative model—the 'oblique rotator'—has been suggested for spectrum variables, in which the dipole axis makes an angle $i'$ with the axis of rotation, while the latter, fixed in direction, has an obliquity $i$ to the lines of sight. Through some unspecified process, the europium and chromium are supposed to have become concentrated near the two magnetic poles of the star. Axial rotation then brings into view the europium and chromium areas alternately, thus causing spectrum variations and reversal of polarity. The observations of *HD* 125248 rule out the oblique rotator on several counts:

(1) The observed rotational broadening is only about half that required by the model.

(2) There is no theory to account for the separation of europium and chromium according to magnetic polarity; but if such a process did occur it would presumably be a specific one, the same in all such stars. Yet in $\alpha^2 CVn$, also a europium–chromium alternator with a reversing field, the maximum for europium occurs with *negative*, not positive, polarity as in *HD* 125248.

(3) The geometry of the oblique rotator leads to the relation $\cos F\pi = (1 + R)/(1 - R)$, where $F$ is the fraction of the cycle during which the polarity is positive, and $R$ is the ratio of extremes of the magnetic field $H_p$. From Fig. 1, $R = -1{\cdot}13$, resulting in $F = 0{\cdot}52$ according to the oblique rotator; yet, in fact, $F = 0{\cdot}65$.

(4) The anharmonic velocity curve, and in particular the rapid deceleration at phase 0·97 (Fig. 2), are incompatible with the oblique rotator.

Accepting the magnetic oscillator as a model for *HD* 125248 and other magnetically variable stars, we find it necessary to graft on to Schwarzschild's model an atmosphere in which large-scale coherent motions occur under the influence of electromagnetic forces, and in which zonal selective separation of various elements occurs symmetrically in the two hemispheres on either side of the equator, conditions at the two poles being the same (except for the sign of the magnetic field).

The conductivity of the atmosphere perpendicular to the lines of force will be very low except for the brief intervals when the changing field is near zero; hence, while $H$ is changing rapidly, an E.M.F. of $10^{13} \cos^2 \varphi$ volts is induced on latitude ($\varphi$) circles around the star; this E.M.F. drops to zero and is reversed when the sign of $dH/dt$ is reversed. The oscillating electric field intensity, $E$, at maximum is of the order of 50 volts/cm. around the equator; its value at any point on the star or in the vicinity can be calculated if the distortion of the dipole field is negligible or is known. If the star is, in fact, in rapid rotation, there will be superposed on the foregoing effect an electric quadrupole field due to the rotation of the star in its own magnetic field[13], and this in turn will oscillate at the fundamental frequency, $\nu_0$.

The velocity of drift of ions in the presence of magnetic and electric fields has two components, a direct velocity $w$ in the direction of $E$ and a transverse (Hall) component, $v$, perpendicular to both $E$ and $H$[14,15]; $v$, which has the same direction for both positive and negative ions, may be resolved into a tangential and a radial component in the atmosphere. Here may be a clue to segregation of ions, for when

$H$ is less than 1,000 gauss, $v$ is dependent upon $e/m$, the ratio of charge to mass of the ion. It appears that heavy ions such as Eu II may attain a differential velocity of several kilometres per second with respect to other elements; but it is more difficult to understand the difference in behaviour between chromium and iron. The mobility of electrons under the Hall effect may lead to an electric quadrupole field of the whole star, oscillating anharmonically.

As a magnetic dipole oscillator, with a frequency $\nu_0$, *HD* 125248 will radiate roughly $10^{12}$ kW.[16]; since for such an oscillator the power radiated varies as $\nu^4$, it will radiate almost equal power on the first harmonic, $2\nu_0$, due to the term $-1{,}600 \cos 2\theta$ (equation 2).

Stars such as *HD* 125248 have already been mentioned as sources of cosmic rays[17,18,19], but now that this object has been identified as a *bona fide* magnetic oscillator, the proposal is on a firmer basis. Ejection of high-energy ions along the dipole axis of the star may occur at certain phases by some such induction process as that suggested by W. F. G. Swann[20] for the acceleration of electrons in the growing magnetic fields of sunspots, aided perhaps by alternating electric repulsion from the poles. While outlying ions in the vicinity of the equatorial plane of the star will likewise be greatly accelerated by the alternating electromagnetic field, it is not immediately obvious that any cosmic-ray particles can escape from the neighbourhood of the star except along the general direction of its axis. The pulsations on Schwarzschild's model are presumably maintained by a slightly enhanced liberation of nuclear energy in the core at a phase when the central temperature reaches a maximum. The electromagnetic field may be regarded as an intermediary agency capable of transferring energy from the oscillating interior to ions in the outer atmosphere. In short, energy for the acceleration of ions external to the star is supplied by the same nearly inexhaustible source that maintains the star's radiation. Whether or not the accelerating process is so efficient, and magnetically oscillating stars are so numerous, that the galaxy has been populated by energetic cosmic-ray particles from such sources, it can scarcely be doubted that in the vicinity of each such magnetic oscillator there is trapped a local swarm of high-energy ionized particles, moving under the control of the electromagnetic field.

The possibility that in the 22-year solar cycle we see a slow, residual magnetic oscillation of small amplitude is suggested by the cyclic changes in the form of the coronal streamers[21], and by the reversal of polarity in sunspot pairs which may be regarded as a secondary phenomenon, not observable except in the sun.

The stellar magnetic effects so far observed give substance to electromagnetic theories of cosmogony that were formerly speculative. K. Birkeland[23] and Alfvén[22], following the work of C. Störmer[24], have advanced theories of the development of planetary systems based largely on electromagnetic forces. Such theories must now be carefully considered, for in the vicinity of a star having a magnetic field of a few kilogauss, the electromagnetic forces on ions are stronger than those of gravity. Oscillations of the field of a star may eject ions, many of which, following the magnetic lines of force, are concentrated toward the equatorial plane; regional segregation of types of ions in this plane may occur in parallel with the observed zonal concentrations on stars; the oscillating motion of ions will accelerate processes of accretion when dust particles or larger bodies are present; angular momentum will be transferred by the field from a rotating star to an outlying ion cloud, thus in time reducing the axial rotation of the parent star to a low rate and causing a corresponding reduction of the fixed component of dipole moment by de-energizing the primary field-generating process.

Additional data will appear in the *Astrophysical Journal*.


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# AN APPROACH TO X-RAY MICROSCOPY


By Prof. PAUL KIRKPATRICK

Stanford University, California


THE literature of X-rays contains many references to the supposed impossibility of focusing such radiations with lenses or mirrors. Röntgen's early experiments convinced him that the new rays could not be concentrated by lenses, and his successors through several decades have shared his pessimism and his disappointment. The sense of regret is easily appreciated, for satisfactory X-ray microscopy would open up fields of investigation closed to the optical microscope because of its limited resolution, and to the electron microscope because of the limited penetrating power of electrons.

Although all substances refract X-rays, the effect is so slight as to be difficult of detection. An ordinary spectacle lens has an X-ray focal length of the order of one hundred kilometres. Other materials than glass would provide more optical power; but unfortunately all such materials are strongly absorbent. No substance exists which is both transparent and highly refractive to X-rays, and it seems quite certain that none ever will.

The possibility of reflexion optics seems at first only slightly more encouraging. Crystal reflexion is weak and highly susceptible of chromatic aberration. It is doubtful, furthermore, whether the structural perfection of crystals is high enough to meet the demands of microscope-image formation. There

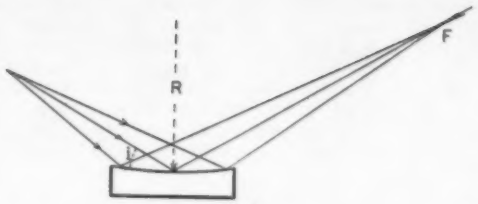


Fig. 1

remains the alternative of total reflexion, an effect not dependent upon the crystalline nature of the reflector. This total reflexion differs from the total reflexion of ordinary light in that it is external rather than internal, and this is a definite advantage; but it suffers from the disadvantage that reflexion occurs only for rays incident upon the reflecting surface at a very small grazing angle—usually less than one degree.

In spite of the restriction to small grazing angles, some image formation is possible. If a small source of X-rays is placed before a concave mirror as in Fig. 1, the reflected rays, following the usual law of reflexion, will converge to a focus near the point $F$. The mirror may exert a considerable power of convergence over incident rays which diverge in the plane of the figure; but it is exceedingly weak in its effects upon ray divergence in the plane normal to the drawing. If the mirror has spherical curvature, its focal length for the first-mentioned group of rays is $Ri/2$, while for the normal plane the focal length has the much greater value $R/2i$. In these expressions, $R$ is the radius of curvature of the surface and $i$ is the small grazing angle of incidence, expressed in circular measure.

Naturally the image is extremely astigmatic, a point object giving rise to a line image; but Mr. A. V. Baez and I have found it possible to correct this astigmatism by crossing the first mirror with another, oriented as shown in Fig. 2. This resultant effect is quite in analogy with the correction of astigmatism in the human eye by the use of a spectacle lens with a complementary astigmatism. Rays proceeding from a point source in Fig. 2 are reflected in turn by the two mirrors and converge to a point image. It follows that an extended object forms by this system a correspondingly extended image, which may be either magnified or diminished in dependence upon the position of the object. This two-mirror system is the basic unit in the attempts being made in this laboratory and elsewhere to develop an X-ray microscope.

Fig. 3, the X-ray image of a bit of metal gauze, was obtained by interposing the gauze between the target of an X-ray tube and the first mirror of a pair

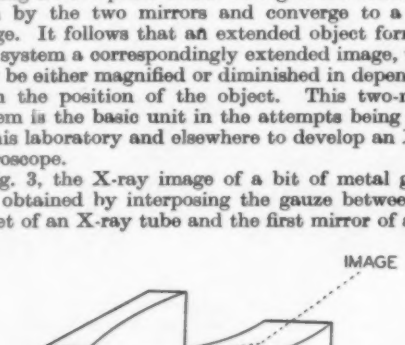


Fig. 2

like that shown in Fig. 2. The photographic film was placed so as to receive the twice-reflected rays at the position of best focus. The magnification, which is noticeably different in the vertical and horizontal directions, was about 50; but the reproduction shown here has been further enlarged so that the over-all magnification is about 500 fold. Small nodules of dense material, formed in the electrolytic process used to produce the gauze, are plainly reproduced in the image. Their diameter is estimated at approximately one micron. Since the theoretical focal surface is quite oblique to the reflected rays, a photographic film normal to these rays records an image which is in correct focus at one point only. In Fig. 3 this point is close to one of the small metallic excrescences, and here the outline of the metal is rendered with a sharpness limited by the grain of the film used. The precision with which the edge may be located on the photographic image indicates a positional uncertainty of one wave-length of visible light at the object.

Fig. 3

Fig. 4 is a Röntgen micrograph of a fragment of a foraminiferan skeleton with natural perforations about 1 micron in diameter. Neither of these micrographs reveals anything new about the subject material; they are presented only as samples of what is possible at present.

Most of the mirrors which have been used in this laboratory have been made of glass by conventional methods and then topped with a thin coat of heavy metal, applied by evaporation in vacuum. The metal coat provides a larger critical angle of reflexion than would be possible with glass alone. The finished mirror surfaces are spherical with radii of curvature of 10 to 100 metres. It is not necessary that the two mirrors of a pair be alike in curvature. Attempts have been made to form aspherical reflectors by selective condensation of metal vapour upon glass surfaces. The method provides great freedom to build surfaces of arbitrary form; but the polish of such surfaces is inferior wherever layers of the order of a wave-length of ordinary light must be deposited. In the hope of improving this process, we are now engaged in a thorough study of the many variables affecting the character of the condensed metal surface.

The desirability of aspherical surfaces has been suggested; actually our spherical mirrors have a rather bad spherical aberration which could be removed by resort to mirrors of elliptical profile.

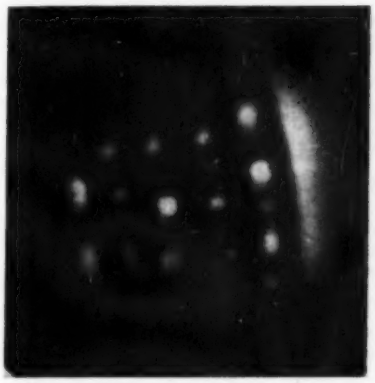

Fig. 4

This one change, however, would not result in ideal image formation, for the defects of a small field, oblique focal surface, and non-uniform magnification would still be present. It now appears that these faults cannot be remedied in any single system like that pictured in Fig. 2, and that compound systems, containing at least two pairs of mirrors, must be employed. We have made some progress with the theoretical optics of such systems and are now engaged in experimental tests. So far as we have been able to learn, grazing-incidence image formation has been completely neglected by optical theorists. One may hope that the possibilities of X-ray microscopy will attract theoretical workers to the problems of these compound, aspherical, anaxial systems.

The small wave-lengths of Röntgen radiation provide the possibility of high resolution, but X-ray microscopy as at present conceived shares with electron microscopy the restriction to very small angular apertures. In the case of X-rays, the aperture angle is flatly limited by the critical angle of total reflexion. The angular limitation may be raised by utilizing rays of greater wave-length; but the net effect upon resolving power is nil. It can be shown that the theoretical maximum resolving power is such as to separate point objects about 70 A. apart. Such performance would require perfect mirror surfaces of the best material now known to exist, and would require that the optical system be filled with coherent radiation. We do not yet have a design which could be expected to approach such characteristics.

The lack of dependence of resolving power upon wave-length leaves the choice of radiation open to other considerations. There are strong reasons for choosing a rather soft radiation: the critical angle increases with the wave-length, and this simplifies certain aberration problems and makes for better light-gathering and hence more photographic speed. Although the magnified X-ray image can be viewed on a fluorescent screen, an adequate photographic exposure on fine-grained film requires many minutes with our present X-ray sources. Soft radiation has the further advantage of providing good contrast when used for the observation of thin specimens of organic material. We have photographed many images with radiation of wave-length between two and three angstroms. Such radiation is so soft as to be strongly absorbed by air, so we enclose the entire optical system in a container filled with helium at a pressure of one atmosphere. Final focusing in all our optical systems is accomplished by tilting the mirrors slightly by means of a micrometer control so as to vary the angle of incidence and hence the focal length.

Reflecting systems are free from chromatic aberration, so from the point of view of image formation there is no reason to desire monochromatic radiation. In thin specimens, however, contrast is impaired by hard components in the beam, so there would seem to be advantage in the use of a high-pass filter which would remove the short waves. But this is precisely the effect of total reflexion at the mirrors; wave-lengths greater than a critical value, dependent upon the material of the mirror and the angle of incidence, are strongly reflected and shorter waves are absorbed in the mirror. Thus we have available a selective process furnishing a considerable degree of voluntary control over image contrast.

Although it does not now seem possible that X-ray microscopy can attain the resolving power which has already been reached by electron microscopes, the X-ray methods have other features which may reserve for them a unique field of usefulness. In X-ray examination of biological materials there would be no necessity for subjecting the specimen to the desiccating action of high vacuum. The range of penetrating powers available in the X-ray spectrum is extremely wide, meeting the demands of biologists on one hand and of metallurgists on the other. Furthermore, the absorption of X-rays is so specifically characteristic of the absorbing element that one may speculate hopefully upon the possibility of microscopic chemical analysis through photographic observation with a succession of approximately monochromatic radiation bands.

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# OBITUARIES

## Admiral Sir A. Mostyn Field, K.C.B., F.R.S.

THE passing of Admiral Sir A. Mostyn Field, who died on July 3 at the age of ninety-five years, severs one of the few remaining links with a period conspicuous for the achievements of British seamen in the field of hydrography. He entered the Royal Navy as a cadet in 1868, and at the examination for lieutenant in 1876 he obtained the unique distinction of full marks in navigation and pilotage, being awarded the Beaufort Testimonial. In the same year, the year following the return of the *Challenger* Expedition and the year of the return of the last officially sponsored British Arctic Expedition in the *Alert* and *Discovery*, Field commenced his career as a hydrographic surveyor and spent the next twenty-three years almost continuously surveying in foreign waters. Many of his surveys remain the sole authorities for the areas concerned. During 1876–80 he served in the *Fawn* under Commander W. J. L. Wharton, surveying on the east coast of Africa, in the Mediterranean, Red Sea and Sea of Marmora. In 1881 at the youthful age of twenty-six he was employed on detached duty surveying the entrances to various rivers in the Niger Delta, after which he joined the *Sylvia* for surveys in the Magellan Strait and later on the east coast of South Africa.

Field obtained his first command, still as a lieutenant, in the *Dart* in 1885, and during the ensuing four years executed a large number of surveys, mainly

in New Guinea and the off-lying islands and in Tasmania. As a commander, in charge of the *Egeria*, he spent the years 1890–94 on surveys in Borneo, Hong-Kong, Singapore, and Malacca Strait. Promoted to captain in 1895, he resumed sea service in 1896 in command of the *Penguin*, in which during the next three years he made a number of surveys in the North and South Pacific and on the Australian coasts. Among these was the well-known survey and borings at the Funafuti Atoll under the auspices of the Coral Reef Committee of the Royal Society in 1897. This was the end of his foreign service. During 1900–4, in command of the *Research*, he carried out surveys mainly in Irish and Scottish waters.

In 1904 he succeeded Rear Admiral Sir William Wharton as hydrographer of the Navy. During his five years period of office he continued the large programme of surveys at home and abroad in the tradition of his predecessors; one of the most notable was that of Scapa Flow with a view to its use as a fleet anchorage, a proposal first submitted to the Admiralty by Graeme Spence in 1812. By increasing and raising the status of the civilian technical staff within the Hydrographic Department, Field greatly increased its capacity to utilize for British hydrographic publications the results of foreign hydrographic surveys which had steadily grown in number and quality since the end of the nineteenth century. Subsequent needs in the First World War amply vindicated his vision.

Field wrote easily and with clarity. He contributed numerous articles on hydrographic surveying, its methods and apparatus to various scientific journals and the "Encyclopedia Britannica" (tenth edition). He revised and enlarged Wharton's famous original work "Hydrographic Surveying" for the third and fourth editions in 1909 and 1920. He was elected a fellow of the Royal Society in 1905 and made K.C.B. in 1911.

After vacating the post of hydrographer of the Navy, Field served as Admiralty representative on the Port of London Authority during 1909–25, as acting conservator of the River Mersey 1910–30 and as nautical assessor to the House of Lords. In his private life he took a great interest in the problems concerning science and religious dogma, and he maintained an active correspondence with a number of theologians pressing for changes in doctrine which would admit many more men of science into the Anglican Church.

G. B. S.

## Dr. R. V. Norris

Dr. Roland Victor Norris died at Port Shepstone, South Africa, on April 28, at the age of sixty-two. He went to South Africa in November 1949 on holiday, and was due to return to the Tea Research Institute of Ceylon, of which he had been director since 1929. His death is a sad loss to the Institute he served so well, and a personal misfortune to his many friends, among whom may be included the whole of his staff.

After graduating from the University of Manchester, Dr. Norris became private assistant to Prof. W. H. Perkin. Moving to the Lister Institute of Preventive Medicine, London, in 1910, he joined Prof. Arthur Harden's school and took part in the classical researches on the mechanism of alcoholic fermentation by yeast enzymes, for which work he was eventually awarded the D.Sc. degree of the University of London. In 1912, while at the Lister Institute, he was elected to a Beit Memorial fellowship.

Dr. Norris's long career in the East began in 1914, when he accepted the post of physiological chemist at the Imperial Bacteriological Laboratory in India. His first administrative experience was gained in the Indian Army, in which his administrative abilities were soon recognized after a brief period of active service in 1915. From 1918 onwards, Dr. Norris gradually turned towards agricultural research, first becoming agricultural chemist to the Government of Madras. When professor of biochemistry in the Indian Institute of Science, Bangalore (1924–29), his research students were largely occupied with biochemical problems relating to agricultural subjects such as soils, plants, manures, the lac industry and the spike disease of sandalwood.

In 1929, Dr. Norris was appointed to the directorship of the Tea Research Institute of Ceylon, when the construction of the permanent quarters at St. Coombs was just starting. The Institute has grown from its foundation on St. Coombs Estate to its present status under his guidance, and will be a memorial to his industry so long as it exists.

'R. V.', as he was known to his colleagues, was by no means a pedant. He was a widely travelled and well-read man of many interests. He was actively interested in sports, particularly rugby and hockey, and took a full part in many social activities. In his later years he became keenly interested in freemasonry and achieved the rare distinction of occupying the chairs of two Lodges under the English Constitution and one under the Irish Constitution.

European, Indian and Singhalese colleagues of two generations, and many members of the tea industry, will remember 'R. V.' with affection. Having worked under his direction for sixteen years, I can pay tribute to his tolerant but firm direction, critical but staunch support, and his fatherly guidance and encouragement.

J. Lamb

## Dr. Otto A. Beeck

Dr. Otto A. Beeck, associate director of research, Shell Development Co., California, died suddenly on July 5. He was born on October 21, 1904, in Stettin, Germany. He was educated in Europe, following which he was post-doctorate research fellow at the California Institute of Technology during 1930–33, serving also as instructor. He joined the Shell Development Co. at Emeryville, California, in 1933 and organised there a broad programme of fundamental research in physics and related aspects of chemistry. He became head of the newly created Physics Department in 1936 and was made an associate director in 1942.

Prior to joining the Shell Development Co., Dr. Beeck carried out research in gas discharges. Since then he has engaged in research on catalysis, the physics and chemistry of surface phenomena, the study of reaction mechanisms by tracer methods, and the fundamentals of lubrication. He was a member of the National Research Council's Committee on Catalysis and of the Sub-Committee on Lubrication, Friction and Wear of the National Advisory Committee for Aeronautics. He was active also on the Advisory Council of the American Institute of Physics.

Dr. Beeck was interested in art, photography and ski-ing, and was an amateur farmer and horse fancier.

# NEWS and VIEWS

## Physics at Birmingham : Prof. P. B. Moon, F.R.S.

PROF. P. B. MOON has been appointed Poynting professor and head of the Department of Physics in the University of Birmingham in succession to Prof. M. L. E. Oliphant, who recently resigned in order to direct the School of Physical Sciences in the Australian National University, Canberra (see *Nature*, July 8, p. 54). Prof. Moon's early researches in the Cavendish Laboratory, Cambridge, were in the field of thermionics ; but his interest in nuclear physics soon asserted itself. During a period at the Imperial College of Science and Technology, London, he collaborated in the first experiments using the neutron velocity-selector technique, and, on his appointment to the staff of the Physics Department, University of Birmingham, he continued neutron experiments up to the outbreak of the Second World War. During the early years of the War he was a member of the Birmingham team working on the design of centimetre transmitting valves. Following the successful development of the magnetron, most members of this group were invited to work on the Atomic Energy Project, and Prof. Moon spent the latter years of the War at Los Alamos, in the United States, as a member of the British team under Sir James Chadwick. After the War he returned to work with Prof. Oliphant in Birmingham and accepted a chair of experimental physics in the University. He was elected a fellow of the Royal Society in 1947, and his book, "Artificial Radioactivity", was published in 1949. Prof. Moon takes charge of the Department at a time when the post-war programme of machine construction is approaching completion. An external beam has been obtained in the 60-inch cyclotron which is working well, and the proton synchrotron is in an advanced stage of construction. We may expect, therefore, that in the next few years the Birmingham school will contribute many and varied researches in the field of nuclear physics.

## International Research on Flame Radiation

MEN of science and engineers from France, Holland and Great Britain, to be joined later by a Swedish scientific worker and observers from the United States, are co-operating in an investigation of the factors affecting luminous flame radiation, using an experimental furnace in the Royal Dutch Steelworks at Ijmuiden. Flame radiation is of great importance in relation to the mechanism of heat transfer in furnaces and boilers ; but very little is yet known on the subject. At the end of 1948, therefore, it was decided to start this joint research, and the Royal Dutch Steelworks made available its experimental furnace, which had been built in 1947–48 for the study of the radiation from oil flames of a size comparable with those in open-hearth steel-making furnaces. It was agreed that two kinds of trial should be carried out : in the first, which are done on an engineering scale, a large number of independent variables such as fuel-rate, kind of fuel (various oils, pitch, pulverized coal, coke oven gas), kind of burner or port, excess air ratio, etc., are altered systematically and a limited number of radiation, temperature and combustion properties of the flame are measured for each flame setting ; in the second, or 'scientific' trials, a relatively small number of different flame settings are to be studied in great detail by means of probes, so that, for example, the course of combustion of individual droplets, the mechanism of soot formation and the emissivity and temperature of different parts of the flame can be elucidated in detail. It is probable that this latter, fundamental investigation, though more difficult, will yield more useful results than the former, empirical method. It was decided to choose five variables—creosote pitch against oil, high and low combustion air-rate, high and low fuel-rate, high and low atomizing medium flow-rate, and air against steam as atomizing medium —and to carry out forty-eight trials according to a factorial scheme.

The work is supervised by committees set up in the three countries, each supported by many firms and organisations in their own country, and the respective chairmen are : France, Prof. G. M. Ribaud, director of research of the French Gas Industry, and director of the Laboratoire des Hautes Températures ; Great Britain, Prof. O. A. Saunders, Imperial College of Science and Technology ; and Holland, Mr. J. E. de Graaf, chief of research of the Royal Dutch Steelworks. A joint committee of the three countries has been set up to co-ordinate the work, with Prof. Ribaud as chairman, and each national committee has appointed two representatives. In charge of the research programme as a whole is Mr. M. W. Thring, head of the Physics Department of the British Iron and Steel Research Association. Further details of this work are available from the Secretary, Flame Radiation Research British Committee, c/o B.I.S.R.A., Physics Laboratories, 140 Battersea Park Road, London, S.W.11.

## Manchester Joint Research Council : Report for 1949

THE annual report of the Manchester Joint Research Council for 1949 covers the fifth year of the Council's existence and stresses the Council's study of the application of the technique of operational research to industry and of the questions surrounding the use by industry of the university graduate. As a first step the Council arranged six meetings, five of them lectures on progress made in particular industries or spheres of interest by use of the techniques developed during the Second World War, and the sixth being an open forum ; the response indicates that this venture was the most rewarding on which the Council was engaged. In May 1949 the Council convened a very successful conference on "The Place of the Graduate in Industry". Although insufficient progress has been made with the investigation of the scientific needs of industry in the north-west of England for an interim report to be presented, much time has been given to the clarification of the problems involved, and the financing of the venture has been discussed with the Department of Scientific and Industrial Research. The report of Mr. A. D. Butchart, the executive liaison officer, appended to the Council's report, gives examples of the liaison and information service rendered to industry, including problems on the disposal of waste materials, the utilization of flax straw and shives, lignin as a by-product from the paper industry and new designs for machinery. Mr. Butchart has also served on a committee appointed by the Regional Advisory Council for Further Education for Manchester and District to determine the facilities, staff, etc., available for sponsored research in the various technical colleges in the area.

## Swelling of Wood under Stress

An interesting experiment has been made at the Svenska Träforskningsinstitutet, Stockholm, in organising a series of lectures by foreign men of science who address the Institute on their own specialized subjects connected with wood and paper. In this connexion a course of lectures was given in the Institute during March 1948 by Dr. W. W. Barkas, of the Physics Section of the Forest Products Research Laboratory, Princes Risborough, and industrial men of science from several Scandinavian countries attended. Briefly, the lectures provide a descriptive account of the fundamental work done during 1940–48 by the Physics Section of the Laboratory on the thermodynamics of the swelling of gels, and refer particularly to wood, wood fibres and paper. The swelling stress methods are important in dealing with porous bodies, where external mechanical behaviour gives no precise indication of the elastic and plastic properties of the constituent gel, and also in the study of stresses set up under different conditions. The lectures are issued in book form, entitled "The Swelling of Wood under Stress", under the auspices of the Department of Scientific and Industrial Research by the Forest Products Research Laboratory at Princes Risborough (pp. 103; London: H.M. Stationery Office, 1949. 6s.) and deal with: (1) structure, sorption and swelling; (2) anisotropic elasticity; (3) swelling stresses in elastic gels; (4) plasticity; and (5) sorption hysteresis. The Director of Forest Products Research gives a brief foreword saying that it is hoped that the book will prove of interest and assistance to workers not only in the physics of timber but also in the wider field.

## Junior Colleges in Scotland

A Scottish committee under the chairmanship of Mr. J. B. Frizell, director of education, Edinburgh, and including representatives of a number of important Scottish firms and educational bodies, has been considering the aims, objectives and organisation of junior colleges to be set up under the Scottish Education Act of 1946. These junior colleges are the Scottish counterpart of the county colleges to be set up in England under the Education Act of 1944. A report of the Scottish committee's findings has now been published by the British Association for Commercial and Industrial Education, and, while it deals particularly with the special characteristics of the Scottish scene, contains a great deal of informative material that will be of value to all engaged in further education. Many of the suggestions in the report could find immediate application in the various schemes for part-time day release of young workers in England and in Scotland. Copies of the report may be obtained from the British Association for Commercial and Industrial Education, Management House, 17 Hill Street, London, W.1.

## Archæology of the Florida Gulf Coast

Vol. 113 of the Smithsonian Miscellaneous Collections, entitled "Archeology of the Florida Gulf Coast", by Dr. Gordon R. Willey (Publication 3988; pp. 599+60 plates; Washington, D.C.: Smithsonian Institution, 1949), is an important and comprehensive report covering the whole of the coastal region of western Florida except for the subtropical area in the south. Dr. Willey carried out a survey and excavations which enabled him to establish a detailed succession, and, as a result, he has been able to incorporate the results of older work, much of it of a less exacting standard than his own, in a connected whole. The succession is expressed in terms of the three major stages with which we are familiar in the south-east, namely, Archaic, followed by Burial Mound and Temple Mound, with the modifications necessary for a rather marginal area. The survey was full enough even to enable provisional estimates of population to be made, and it can be regarded as the last word in regard to the area concerned for the foreseeable future, except in so far as radiocarbon dates for the earlier cultures can be obtained. It would be helpful if the Smithsonian Institution would provide an index to works of this length.

## Seismological Observations of the Heligoland Explosion of April 18, 1947

Much of the seismic work connected with the explosion of munitions, which took place on the island of Heligoland on April 18, 1947, has now been published ("Seismic Waves from Heligoland Blast of 18 April, 1947". By J. Pomerantz, Cmdr. B. Perkins, jun., J. V. Atanasoff, K. S. Bonwit. U.S. Naval Ordnance Laboratory Report No. 1080, Pt. 1, November 1948; "Seismic Experiments on the North German Explosions 1946 to 1947". By P. L. Willmore. *Phil. Trans. Roy. Soc.*, A, 242, 123, August 1949). The chief advantage to seismology of this large explosion was that the initial time of the shock was pre-arranged and later verified by means other than seismic, and also that additional observations to the existing normal observatory ones were made using seismographs especially constructed for the purpose and employing a very open time-scale for the accurate reading of onsets. The explosion took place at 10h. 59m. 58·5s., G.M.T., from an epicentre in lat. 54° 11′ N., long. 7° 53′ E., and had a thermal energy of $1{\cdot}3 \times 10^{20}$ ergs. The energy of the seismic waves was $10^{17}$ ergs. The above two reports used largely independent data and at some time will have to be correlated; but approximate average results using these data appear to show that the earth's crust in that part of Europe covered by the observing stations has a total thickness of some 30 km. as measured from the earth's surface to the top of the basaltic layer or mantle. It appears to consist of three layers: at the top, sedimentary of thickness 6 km.; second, granitic of thickness 10 km.; and third, intermediate of thickness 14 km., resting on the basalt. The approximate average velocities of the primary or longitudinal waves in the three layers appear to be sedimentary, $P_s = 4{\cdot}6$ km./sec.; granitic, $P_g = 5{\cdot}5$ km./sec.; and intermediate, $P^* = 6{\cdot}6$ km./sec. The velocity of the $P_n$ waves in the underlying basalt or mantle was 8·2 km./sec.

## Commission of Inquiry into South African Museums

In 1948 the South African Government appointed a Commission of Inquiry to investigate the scope, finances, etc., of the Union's principal museums, art galleries, and botanic and zoological gardens. The Commission's report has now been presented to Parliament. Of the several recommendations made, the most far-reaching is probably that which relates to the establishment of a national council to advise the Minister of Education on all matters connected with these institutions. Formerly, the Union's museums, art galleries, etc., were under the Ministry of the Interior; at present they come under the

Ministry of Education. Any such council, composed of persons acquainted with present-day museum methods and aims, and with a personal knowledge of the movements and trends that are taking place in the museum service elsewhere in the world, should mark an important stepping-stone to the better development of the South African service. The report also recommends that the State-aided institutions should receive greater financial support; that the museums should undertake more historical research, and that for this purpose properly trained historians should be appointed to museum staffs; that the costs of museum publications should be paid by the State; and that one Parliamentary Act should be passed to control all the Government-aided institutions. It is also recommended that the maintenance and extension of museum services for schools should be the responsibility of the respective provincial authorities.

## Pasteur Institute of Southern India

THE annual report of the Director of the Pasteur Institute of Southern India, Coonoor, published together with the forty-second annual report of the Central Committee of the Pasteur Institute for the years 1948–49 (pp. 46; Madras: Diocesan Press, 1949), shows that the Institute, since its foundation in 1907, has done excellent work. The report deals with the antirabic treatment of human patients and animals, and the Institute's research work on rabies and cholera, its blood bank and routine investigations, and the work of its nutritional research laboratories. The number of human patients treated for rabies at the Pasteur Institute during the years 1907–48 was 41,131, the mortality being 0·99 per cent. During 1922–48 226,265 patients were treated at subsidiary centres, and the death-rate among them was 0·33 per cent. The number of animals prophylactically treated against rabies between 1923 and 1948 was 14,212, the death-rate among them being 1·42 per cent. For human patients and animals, the Institute manufactures, by Semple's method, a 5 per cent suspension of sheep brain (Paris strain of fixed virus) in carbol saline. The vaccine is issued to various centres in India and to veterinarians. Since its foundation in 1942, the blood bank has prepared more than 151 litres of plasma, which has been issued to various civil, military and mission hospitals.

## Education of the Young Worker

ORGANISED by the Oxford University Department of Education in association with representatives from industry, and educational and social services, the second Oxford conference dealing with the education of the young worker considered young people's entry into work under the special aspects of guidance and initiation. An attempt was made to treat guidance as widely as possible; but the conference tended to concentrate on vocational guidance in the more technical and specific sense. The general subject was considered concurrently by eight commissions under the headings of: (1) review of the present situation; (2) vocational guidance of the worker; (3) the juvenile; (4) the job; (5) the vocational guidance service. Each day's deliberations were preceded by a series of talks dealing with the particular subject under consideration; in addition, young workers themselves were represented by a haulage hand in the mining industry and a dictaphone typist to a mixed club, who made a most significant and valuable first-hand contribution to the conference. The conference was supported by the King George's Jubilee Trust, on whose behalf a report has now been published. It may be obtained from the Oxford University Press, price 2*s.* 6*d.*

## Canadian Awards for Postgraduate Research

THE National Research Council of Canada has awarded 197 scholarships, totalling 140,225 dollars, for postgraduate research in 1950–51, which are grouped in the following five classes: postdoctorate overseas followships, eight at 2,500 dollars; special scholarships, six at 750 dollars; fellowships, twenty-one at 900 dollars; studentships, eighty-one at 750 dollars; and bursaries, eighty-one at 450 dollars. Of the eight postdoctorate overseas fellowships, two will be held at Bristol, four at Cambridge and one each at Coimbra and Oxford; of the winners of the six special scholarships, two will work at Oxford, and one each at California, Dublin, Massachusetts Institute of Technology and Michigan. The other awards will be held at Canadian universities. The distribution of awards by branches of science in which the holders will work covers the following nine fields: chemistry, 67; physics, 54; biology, 27; engineering, 12: geology and mineralogy, 11; metallurgy, 8; mathematics, 7; biochemistry, 6; and medical research, 5. These five medical research scholarships are in addition to the medical research fellowships awarded by the Division of Medical Research.

## Biological Hazards of Atomic Energy

A TWO-DAY conference is being arranged jointly by the Institute of Biology and the Atomic Scientists' Association, and with the support of the British Association, on the subject of atomic energy and its biological hazards, and will be held at the Royal Institution, Albemarle Street, London, W.1, during October 20 and 21. Other societies interested in the meeting include the British Institute of Radiology. The object of the conference is to consider, on the basis of the available facts from both the biological and physical aspects, the possible biological hazards arising from the development and application of atomic science now and in the future. The meeting will comprise four sessions as follows: (1) biological and medical effects of nuclear radiations; (2) tolerance-levels and measures of protection; (3) biological implications; (4) atomic energy and the future. In each session, opening addresses will be given by invited speakers, and discussion will follow. Preliminary arrangements are being made by a joint committee, of which the chairman is Prof. Alex Haddow, Chester Beatty Research Institute, Royal Cancer Hospital, Fulham Road, London, S.W.3.

## Announcements

THE 289th meeting of the Biochemical Society will be held in Derby Hall, University of Liverpool, N. Mossley Hill Road, Liverpool 18, on September 22, at 11 a.m., and will take the form of a symposium on "The Biochemistry of Fish".

ERRATUM. We are informed that in the communication entitled "Marching in Locust Hoppers of the Solitary Phase" in *Nature* of July 22, p. 151, Table 1 is incorrect and should be replaced by the following:

Table 1. MARCHING SPEEDS (cm. per sec.)

| | | | |
|---|---|---|---|
| Solitary hoppers. | Mean 1·33 | S.E. ± 0·35 | S.D. ± 1·59 |
| Gregarious ,, | ,, 3·27 | S.E. ± 0·41 | S.D. ± 1·85 |

The difference between the means is 3·6 times the standard error and therefore significant.

# MECHANISM OF THE BETA-AMYLOLYSIS OF AMYLOSE

By Dr. E. J. BOURNE
University, Birmingham 15

AND

Dr. W. J. WHELAN
University College of North Wales, Bangor

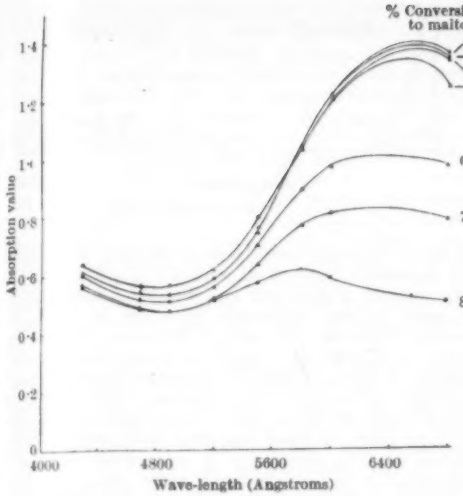
THE mechanism by which beta-amylase degrades amylose has been the subject of recent papers by Swanson and Cori[1-3] and by Cleveland and Kerr[4,5]. These authors hold the view that, during beta-amylolysis, an enzyme molecule attaches itself to an amylose molecule, and, by the stepwise removal of maltose units, degrades it completely before it attacks another polysaccharide chain ('single-chain' theory). An alternative proposition is that collisions between beta-amylase molecules and substrate chains may affect the liberation of only one maltose unit at a time from each chain, with the result that all the amylose chains will be shortened simultaneously and at approximately the same speed ('multi-chain' theory). If the beta-amylolysis of amylose proceeds according to the 'single-chain' theory, then at any time during the course of the reaction there will be present (i) unattacked amylose, (ii) maltose, and (iii) complexes of enzyme and partly degraded amylose. The amount of (iii) present will depend upon the relative proportions of enzyme and substrate, and can be neglected if a sufficiently weak enzyme solution is employed. On the other hand, 'multi-chain' degradation will result in there being present at any intermediate stage (i) maltose and (ii) shortened polysaccharide chains, all of which have been degraded to an approximately equal extent.

We have for some time been endeavouring to find a solution to this problem. Although our evidence cannot as yet be considered to be conclusive, we are prompted by the recent publication of Kerr[5] to present several considerations which conflict with his interpretation of beta-amylolysis through the 'single chain' mechanism.

The evidence presented by Swanson and Cori[1-3] in favour of the 'single-chain' theory was drawn from three independent lines of inquiry. During the beta-amylolysis of amylose, they calculated "the amount of unhydrolysed amylose (*a*) from the amount of undialysable carbohydrate and (*b*) from the amount of maltose formed, the argument being that the formation of intermediate dextrins during the action of beta-amylase should give rise to a discrepancy between the two values" (ref. 1, p. 809). That the results of this experiment cannot decide between the two mechanisms is shown by the following considerations. Since it was stated that the dialysis membrane was permeable to chains having an average length of nine glucose units, intermediate dextrins produced by a 'multi-chain' mechanism would not be sufficiently small to pass through the membrane until about 95 per cent of the polysaccharide had been converted into maltose, and so no discrepancy between (*a*) and (*b*) would be revealed until this stage was reached. In fact, the highest conversion to maltose attained in the experiment was only 80 per cent, and the values (*a*) and (*b*) should have been the same at this stage regardless of which mechanism was operative. That the two values did not coincide was ascribed to the liberation of glucose, which caused the "percentage conversion to maltose" to be estimated at too high a value. This suggested explanation would appear to be unlikely since the beta-amylase was stated to be free from maltase.

Secondly, Swanson and Cori[2] measured the effect of beta-amylolysis on the ability of amylose to function as a primer of the synthetic action of potato phosphorylase. The beta-amylolysis was carried as far as 50 per cent conversion to maltose, and throughout there was a steady decrease in the priming power of the products. These authors pointed out that this decrease could be explained on either of the theoretical mechanisms of beta-amylolysis. It may have been due to a reduction in the number of amylose molecules ('single-chain' degradation) or to a decreased affinity for phosphorylase shown by linear dextrins ('multi-chain' degradation). Although the loss in activating ability was greater than could be explained by a decrease in the number of amylose molecules, Swanson and Cori favour the 'single-chain' mechanism on the grounds that the shorter chains of the amylose had probably been hydrolysed in preference to the longer chains. It has been shown, however, that in the later stages of the beta-amylolysis of amylose there is a sharp peak in the priming power of the products[6]. Such a peak would not be expected if beta-amylolysis proceeds by a 'single-chain' mechanism; but it can be readily explained if a simultaneous degradation of all the polysaccharide chains results in the accumulation of dextrins of such a chain-length (about twenty units) that they show optimum activating ability.

Thirdly, it was shown by Swanson[3] that, during the beta-amylolysis of amylose, the wave-length of peak absorption by the polysaccharide–iodine complex remained constant during the greater part of the reaction, and from this it was concluded that unchanged amylose was present throughout. Now it was demonstrated in the same paper that the iodine complexes of linear dextrins (obtained by synthesis from glucose-1 phosphate) exhibit peak absorption at a constant wave-length, when they are composed of chains more than thirty-three units in length. Clearly, if beta-amylolysis involves a 'multi-chain' reaction, no movement in the wave-length of the absorption peak is to be expected until the later stages of the hydrolysis. In each of three curves which depicted the absorption of the polysaccharide–iodine complexes in the region beyond about 75 per cent conversion to maltose, there was no marked peak between 5800 A. and 7200 A. This was due to the low intensities of the iodine stains, caused primarily by the withdrawal of a constant volume of the digest, and, therefore, of progressively less polysaccharide, for staining purposes. We have surmounted this difficulty by staining a constant amount of polysaccharide at each stage during the beta-amylolysis of amylose (low enzyme/substrate ratio), the appropriate volume of the digest to be withdrawn being calculated from the reducing power (see graph). It will be seen that between 69 and 86 per cent conversion to maltose there is a marked movement of the absorption peak from 6500 A. to 5800 A., corresponding to a change in the colour of the stain from blue to red-purple. Such a change would be expected, whatever the enzyme/amylose ratio, if beta-amylolysis proceeds according to the 'multi-chain' theory, but only when the enzyme/amylose ratio is high if a 'single-chain' mechanism operates.




Beta-amylolysis of amylose. Light absorption curves of iodine-stained polysaccharides. (The concentration of polysaccharide is the same for each, namely, 1 mgm./100 c.c., the concentration used in the estimation of blue value)

Swanson[2] also directed attention to the fact that when potato phosphorylase is allowed to degrade amylose in the presence of inorganic phosphate, the light-absorption curves of the iodine-stained intermediates follow the same pattern as those obtained during the beta-amylolysis of amylose; this has since been confirmed[6]. Clearly the two enzymes must function in the same way, whether this involves a 'single-' or 'multi-chain' mechanism. Now it is generally accepted that the chain-lengths of synthetic starch-type polysaccharides can be calculated from a knowledge of the number of end-groups available in the primer and the amount of glucose-1 phosphate converted. This implies that the synthetic function of phosphorylase involves the simultaneous apposition of glucose residues to all primer chains. It is highly probable that the mechanism of polysaccharide degradation by phosphorylase is the reverse of that operating in synthesis, and hence there is strong evidence that beta-amylolysis, too, proceeds according to the 'multi-chain' theory.

The evidence presented by Cleveland and Kerr[4] in support of a 'single-chain' hydrolysis was based on an examination of the polysaccharides isolated at various stages during the beta-amylolysis of amylose. The method by which the polysaccharides were isolated involved precipitation with butanol and hence there existed the possibility of fractionation, due to selective precipitation of the longer chains. This is evident from the fact that at 91 per cent conversion to maltose only 43 per cent of the calculated amount of residual polysaccharide was recovered. Their argument is based, however, on two residual polysaccharides (*A* and *B*), isolated in 94 and 95 per cent yields at conversion limits to maltose of 28 and 52·6 per cent, respectively. These they regarded as essentially unchanged amylose on the basis of (*a*) their reducing powers, (*b*) their viscosities in ethylene-diamine, (*c*) the molecular extinction coefficients of their iodine complexes, and (*d*) the molecular weights of their acetates.

The reducing powers of *A* and *B* (1·33 and 1·27) were, in fact, lower than that of the original amylose (1·43), whereas they should have been the same on the 'single-chain' theory, or higher on the 'multi-chain' theory. Cleveland and Kerr attributed this unexpected result to the preferential affinity of the beta-amylase for shorter amylose chains; but it may, indeed, have been due in some measure to the preferential precipitation of the longer chains by butanol.

With regard to the molecular extinction coefficients of polysaccharide-iodine complexes, it is not necessarily true that a linear polymer of 200 units will stain appreciably different from an equal weight of one of 400 units. A glucose residue well removed from the ends of a chain most probably is not influenced in its contribution to the staining properties by the length of the chain, and hence equal weights of two long-chain polysaccharides should not show significant differences in their iodine-stains. This is not true of short chains (for example, twenty units), because in this case the terminal glucose units and helices constitute an appreciable proportion of the whole. Hence, in our opinion, the extinction coefficients quoted by Cleveland and Kerr[4] do not help to distinguish between the alternative theories.

The degrees of polymerization of polysaccharides *A* and *B* (330 and 365 units, respectively) were not regarded by Kerr as being significantly different from that of the original amylose (455 units). In fact, the values to be expected from the 'multi-chain' theory are 330 and 220 units. Thus the observed value for polysaccharide *A* is in agreement with this theory, while that for polysaccharide *B* affords no distinction between the alternatives. On the other hand, the viscosities of *A* and *B* in ethylene-diamine appear to favour the 'single-chain' theory.

Although it cannot be concluded that the problem of the mechanism of beta-amylolysis has been resolved beyond doubt, we feel that the balance of available experimental evidence favours the hypothesis of 'multi-chain' degradation. The recent observations of Hopkins and Jelinek[7] lend support to this view.

We wish to express our gratitude to Prof. Stanley Peat for the valuable suggestions which we have received during many fruitful discussions of this topic.

[Jan. 21.

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## ELECTRO-MAGNETO-IONIC WAVES

By Prof. V. A. BAILEY and Dr. K. LANDECKER
University of Sydney

In some recent publications[1,2,3] the general theory of plane electromagnetic waves in an ionized medium pervaded by static electric and magnetic fields, **E** and **H** respectively, has been developed and its use indicated to explain the origin of abnormal solar and other kinds of radio noise.

The most characteristic conclusion to which it leads is that, in general, several frequency-bands exist in which waves can grow with a consequent develop-

ment of strong electromagnetic noise from small random perturbations. When the motions of the positive ions and the electron temperature are neglected, there are three such bands: $B_0$, $B_1$ and $B_2$. When also the electron drift velocity is small compared with the velocity of light and the effects of collisions are neglected, these bands lie approximately in the respective ranges $f_0$ to $f_4$, $f_1$ to $f_3$ and $f_2$ to 0, where $f_0$ is the electron-plasma frequency $\sqrt{Ne^2/\pi m}$,

$$f_1, f_2 = \tfrac{1}{2}\left(\sqrt{f_H^2 + 4f_0^2} \pm f_H\right),$$

$$f_3, f_4 = \tfrac{1}{2}\left(\sqrt{f_H^2 + f_0^2 + 2f_H f_0 l} \pm \sqrt{f_H^2 + f_0^2 - 2f_H f_0 l}\right),$$

$f_H$ is the electron gyro-frequency $= He/2\pi mc$ and $l = \cos\theta$, $\theta$ being the angle which the direction of phase-propagation makes with that of the magnetic field **H**.

These noise-bands are approximately the same as the bands in the ordinary magneto-ionic theory which exclude one or both possible modes of wave-propagation, and conversely no noise is generated when both modes of propagation can occur.

$B_1$ and $B_2$ are respectively the highest and lowest noise-bands. $B_1$ is always completely separate from $B_0$ and $B_2$; but the latter are mutually separate or overlap according as $l^2 + l^4$ is greater than or less than $f_0^2/f_H^2$. When $\theta$ is small, $B_0$ is narrow and all three bands are separate; when $\theta = 0$, $B_0$ does not exist.

Since the theory is of particular interest in explaining the origin and escape of strong radio noise from the neighbourhood of sunspots, it was decided to test its characteristic feature of separate noise-bands by means of experiments with discharge tubes subjected to magnetic fields. As in these tubes the medium is bounded laterally, the appropriate theory involves cylindrical waves and the boundary conditions. The latter theory[4] has not yet been worked out in sufficient detail for our purpose; but the plane wave theory can provisionally take its place, since it is known that circularly cylindrical waves can be represented by cones of plane waves for which the conical angles $2\theta$ may have either real or complex values. Consequently, any experimental demonstration that the application of a magnetic field can give rise to separate noise bands could be taken as evidence in support of the electro-magneto-ionic theory of plane waves.

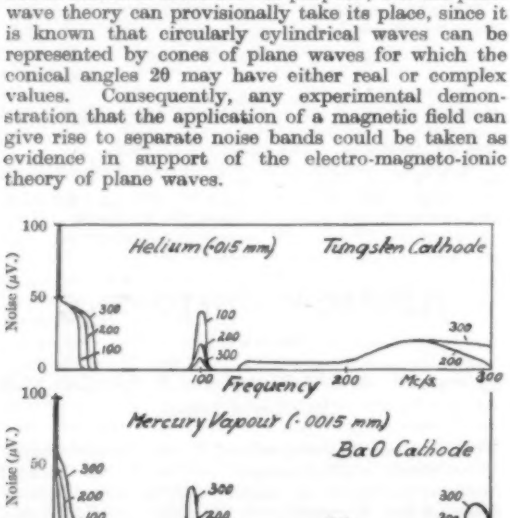


Fig. 1. Longitudinal magnetic field

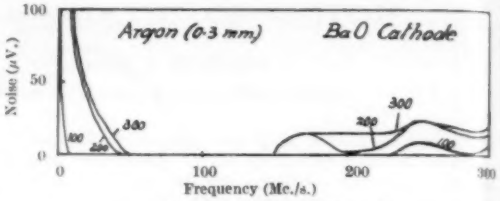


Fig. 2. Transverse magnetic field

Most of the experiments were made with cylindrical glass discharge tubes each with a plain hot cathode or an electron gun at one end and filled with one of the gases helium, hydrogen, nitrogen or argon at pressures between 0·03 and 0·003 mm. of mercury or else with mercury vapour at room temperature. In some of the experiments, opposing pairs of small electrodes, either external or internal, were placed at different sections of the tube; in others a long metal sleeve or pairs of small screened coils were applied externally. The electrodes or coils were connected appropriately to narrow-band radio receivers with a cathode ray oscillograph and output meter attached; for observations below and above 20 Mc./s. the receiver band-widths were respectively 10 and 30 kc./s. The current through the tube was maintained constant, usually at about 20 m.amp.

On applying a uniform magnetic field, greater than 100 gauss, *along* the axis of the tube, the expected separate noise-bands $B_1$ and $B_2$ always appeared; and in the more thoroughly examined situations with helium and mercury vapour, the band $B_0$ also appeared. This noise (which much exceeded the ordinary background noise) always appeared and disappeared with the magnetic field. The observed noise intensities with helium and mercury vapour for fields of 100, 200 and 300 gauss are shown by the curves in Fig. 1, each of which is labelled with its corresponding field. No suitable receivers were available to explore noise above 300 Mc./s., so these curves determine only a lower limit to the values of the upper edges of the observed bands $B_1$.

From the current density and other experimental data, the corresponding mean electron density was estimated to be about $1{\cdot}2 \times 10^8$; this yields the approximate value 100 Mc./s. for the plasma frequency $f_0$; also $f_H$ is given by $2{\cdot}82\ H$ Mc./s. By comparing the observed with the theoretical bands, we can arrive at the following conclusions.

The narrow middle bands $B_0$ lie in the range $f_0$ to $f_4$ when $0{\cdot}6 < l^2 < 1$, that is, when $\theta$ is real and less than 40°; the corresponding plane waves are uniform. The lower edges of the highest bands $B_1$ agree with $f_3$ when $l^2$ is greater than 1·46; this corresponds to pure imaginary values of $\theta$ and non-uniform plane waves. The lower limit of 300 Mc./s. for the upper edges of these bands is of the same order of magnitude as the values of $f_1$. The upper edges of all but one of the lowest bands $B_2$ agree with $f_2$ within a factor of 2. (Even these differences may be removed by considering non-uniform plane wave solutions of the form $\exp.i(\omega t - l_1 x - l_2 y)$ with $Ox$ along the tube axis, $l_2^2$ real and $l_1$ complex in the noise-bands.) Having regard to the fact that the medium is not strictly uniform and varies somewhat with the magnetic field, the observations are in substantial agreement with the theory.

Observations were also made on a thyratron tube 884, which was stated by the manufacturers to contain argon at a pressure of about 0·3 mm. As in the noise experiments of Cobine and Gallagher[5] with the same type of tube, the magnetic field was applied transversely to the current. The receiver was connected between the plate and cathode or, through condensers, between the plate and grid. With a current of 4·4 m.amp. the curves of noise-intensity are shown in Fig. 2. These reveal two separate noise-bands. This again demonstrates the characteristic feature of the theory, even though now the ionized medium is far from uniform, and the electron temperature and collision frequency are not negligible. Our curves agree with the published results of Cobine and Gallagher up to their limiting frequency of 7 Mc./s.

In the experiments with helium and a magnetic field of about 300 gauss, the available noise-power output measured between a long external metal sleeve and the cathode was found to vary between $3 \times 10^{-11}$ and $10^{-10}$ watts (c./s.)$^{-1}$ as the frequency ranged from 0·6 to 15 Mc./s. These outputs correspond to power fluxes through the surface of the beam of between $3 \times 10^{-13}$ and $10^{-12}$ watts (c./s.)$^{-1}$ cm.$^{-2}$. Equipment was not available for measuring the power outputs in the higher bands. It is of interest, however, to mention that in a private communication concerning observations at 100 Mc./s. made on noise from the great sunspot area which crossed the sun's meridian between April 5 and 7, 1947, Dr. J. L. Pawsey estimated that the mean power emitted normally was of the order of $10^{-17}$ watts (c./s.)$^{-1}$ cm.$^{-2}$.

Thus our experiments both demonstrate the value of the electro-magneto-ionic theory in predicting new phenomena and also supply a rough model of a sunspot emitter of enhanced solar noise[6]. The additional prediction that this noise is elliptically polarized remains to be tested. A detailed account of this work will be published in due course.

We owe thanks to Drs. E. G. Bowen and J. L. Pawsey for the loan of receivers, and to Messrs. J. Middlehurst and A. J. Mortlock for their assistance with the experiments.

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# BRITISH CAST IRON RESEARCH ASSOCIATION

By Dr. J. G. PEARCE, O.B.E.
Director of the Association

A BRIEF account was given early in 1947 (*Nature*, **159**, 49; 1947) of the origin and growth of the British Cast Iron Research Association. From mid-1948, as a result of arrangements made with the Joint Iron Council, the two thousand or so iron-foundries in the United Kingdom may become members of the Association simply by signing a form, and, as previously, other interested firms may also join. This arrangement has nearly doubled the annual income, now of the order of £80,000, and two recent extensions have been made.

On May 5, Lord Bilsland opened the new Scottish laboratories on the Blantyre Industrial Estate, Glasgow. The Association maintained a Scottish regional laboratory in Falkirk for more than twenty years, and this has been transferred to a building on the new site, where 5,000 sq. ft. of covered space has been provided. Scotland has roughly one-tenth of the population and a similar proportion of the number of iron-foundries of the United Kingdom, but it has about one-eighth of the tonnage output, the bulk of which is used outside Scotland. The new laboratory is regarded essentially as a part of the Development Department of the Association, concerned with industrial applications, and is equipped for chemical, metallographic and mechanical testing, and sand testing, with auxiliary accommodation and a machine shop. The place of regional laboratories in the Association's final scheme is a matter of considerable interest to the Council. The French counterpart of the Association, the Centre Technique des Industries de la Fonderie in Paris, which has evolved since the War, has established no less than nine regional laboratories, in addition to its central headquarters laboratories and experimental foundries.

On July 5, the president of the Association, Mr. P. H. Wilson, opened some extensions at the Association's headquarters at Alvechurch, Birmingham, consisting principally of new accommodation for the machine and instrument shop and mechanical testing laboratory. The total covered area at Alvechurch is now 20,000 sq. ft., with a total staff of about eighty, and the ultimate development of the Association may require a total staff of about double this figure. A brief account of the organisation and work was given in the reference previously quoted. The staffs of the Research and Development Departments, in addition to their own provisions, can call on the services of a group of laboratories and departments. In addition to the new extensions, these include laboratories for spectrographic work, gases, metallography, chemical analysis, and the testing of sands and refractories. Some new equipment has been added and the total assets of the Association now approach a value of £100,000.

The Physical Metallurgy Laboratory contains platinum-wound furnaces for cooling-curve determinations. It is equipped, as are many of the other laboratories, with Kent potentiometric recorders, and with the Tinsley vernier potentiometer and Tinsley high-speed recorder. In the Metallographic Laboratory, the Vickers projection microscope can be used for vertical illumination, dark-field illumination, the examination of structures under polarized light, and for macro-examination. A wide range of objectives includes a mono-bromo-naphthalene immersion objective, used for high resolution in conjunction with the mercury arc. The Chemical Research Section includes a Uvispek spectro-photometer, and apparatus for the electrolytic isolation of phases in cast iron, a polarograph and absorptiometers. Phase-change study has been facilitated by dilatometers arranged for operation in inert atmospheres and fitted with programme controllers. The Sand Testing Laboratories contain a complete set of equipment for milling, mechanical grading, mechanical testing, in addition to the Association's own apparatus for the determination of evolved gases in core sands and for determining stress-strain curves of sand specimens at normal and elevated temperatures. The Spectrographic Laboratory has a large quartz prism spectrograph, complete with microphotometer

and comparator. The Gases Laboratory is mainly concerned with the determination of oxygen, hydrogen and nitrogen in molten metal, and vacuum fusion apparatus is used, comprising a vacuum system attached to a 30-kVA. valve-oscillator type high-frequency furnace. Bone and Wheeler and Orsat apparatus for gas analysis are available. The Mechanical Testing Laboratory is equipped with a variety of machines for testing ordinary mechanical properties —tensile, transverse, compression, fatigue, impact, hardness, damping—including a 50-ton Avery single ram-type machine for determining mechanical properties at both high and low temperatures. Five types of extensometer are used, including one for elevated temperature tests. The experimental foundry is equipped to provide any of the molten metals within the Association's field and for their subsequent treatment, and immersion pyrometers and temperature recorders are used. The machine and instrument shop has a wide range of modern machine tools, such as are needed not only for the preparation of all forms of test samples, but also for the construction of apparatus made by the Association itself, including, for example, a machine for simulating cavitation erosion in propellers by a Venturi nozzle and a jet impact machine for measuring cavitation erosion; apparatus for annealing in controlled gaseous atmospheres; a 20-way static strain-gauge bridge with calibration beam, and apparatus for thermal conductivity, thermal shock and electrical resistivity. Considerable use is made of electronic control methods.

One of the most recent extensions of activity has been the setting up of a small operational research team to which two of three appointments have been made, for the examination of foundry efficiency. The Association is also considerably interested in problems arising from working conditions in foundries, a solution of which is required, for example, to implement the 1947 report of the Joint Advisory Committee on Conditions in Iron Foundries.

In addition to papers presented by the staff to scientific and technical institutions, reports are issued in the Association's *Journal of Research and Development*, which has now been made generally available. Thirty-three reports, running to 445 pages, have appeared in the six issues published since mid-1949.

## MUSK AND THE MUSK DEER

THE musk deer (*Moschus moschus*) has been divided by modern systematists into five sub-species. The sub-species of the Himalaya region has perhaps not suffered so much at the hands of man as have the other sub-species, and is stated to be still fairly common in parts of Kashmir. But as Colin Matheson (*J. Soc. Pres. Fauna Emp.*, 41; March 1950) has recently stated, all are and have been subject to severe persecution. To-day the musk deer is found in many areas in China and also in forested parts of Manchuria, Korea and Sakhalin Island; thence its range extends into the Amur region through Sibera as far as the Altai and to the West Mongolian Border. It is also found in Tibet and southwards as far as the Himalayas in northern India.

Male and female are much alike; neither carries antlers; but the male is armed with two abnormally long teeth (the canines) in the upper jaw, which is used in fights with rivals. On the abdomen the male carries the so-called musk-pod, into which a gland secretes the musk, generally described as of the colour and consistency of 'moist gingerbread' and which appears to serve for attracting the female.

This musk-pod has unfortunately proved to be a great incentive to the destruction of the animal, musk being in constant demand as raw material in the perfume industry. Like other animal perfume materials, musk is a powerful fixative for plant perfumes, and in addition its scent is so intense that in many finished perfumes it is not subordinate to other odours but is one of the predominant constituents.

The animals are caught by snaring or shooting, which results in the death of many young deer as well as females which have no musk-pods. As a result the musk deer now appears to be on the road to extinction over much of its range. In 1925 the quantity of musk exported from China and Eastern Tibet was stated to amount to about 27,000 Chinese ounces per annum, valued at £100,000. The number of animals killed annually in China and Tibet at that time was estimated to be between 10,000 and 15,000.

So valuable was musk in the perfume industry that attempts were made to prepare artificial musk, the first commercial success being achieved by Albert Baur. The present-day musk xylon is widely used in shampoo powder perfumes but has its greatest application in soap perfumery, as it is stated to give a tablet of soap an indefinable sweetness unobtainable with other substances. Another artificial is musk ketone, stated to be the most widely used among continental perfumers. The third musk, ambrette, is the most frequently used in England. These artificial musks resemble natural musks in odour to a greater or lesser degree, but are quite different from it in their chemical composition. True musk owes its odour to a small amount of one of the ketones, known as muscone. In 1926 muscone was isolated from musk, and since then a number of synthetic products have been prepared which, although similar in chemical structure to natural musk, do not occur in Nature.

Although the use of artificial and synthetic musks has increased during the past twenty years, there is, however, still a big demand for natural musks, and the future of the musk deer is causing considerable disquiet to animal lovers. T. H. HAWKINS

## MUSHROOM RESEARCH ASSOCIATION

### REPORT FOR 1946-48

THE Mushroom Research Association, Ltd., represents a well-directed effort on the part of mushroom growers in Great Britain to obtain new knowledge for their own particular industry. A research laboratory was established at Yaxley, Peterborough, in 1946 [1], and the first report, covering the years 1946–48, is now available, following the provision of financial assistance from the Ministry of Agriculture in 1948.

Dr. R. L. Edwards, director of the Station, describes a wealth of detailed experiment leading to the specification for a successful 'synthetic' compost. This is, of course, necessary because very little horse manure is now available. The 'MRA' compost is made from 315 lb. wheat straw with the addition, at first stacking, of 42 lb. dried blood, 2 lb. of sulphate of potash, 7 lb. ground chalk and 5 lb. gypsum. At the fourth turn

of this mixture, 4 lb. of superphosphate, 10 lb. of gypsum and a trace-element solution are added. Such practical trials as have been made seem to show that the compost is at least as good as stable manure. Mushroom fructifications increase in size by an average of 30 per cent in twenty-four hours. Growth continues after the veil has opened, and, for the rest, the cropping follows known laws—the more mushrooms per square foot, the smaller they will be.

Chemical work reported by S. Burrows shows that *p*H values first rise during composting and later fall. Nitrogen is also lost during the process, the loss being greater if the initial amount of nitrogen is relatively high. Studies of carbon dioxide production, the formation of calcium oxalate by the mycelium, and the effect of various substances on the physical nature of the compost should lead to a more fundamental understanding of this special crop. C. J. La Touche, in the Microbiology Department, describes studies on the effect of various substances on the growth of the mushrooms, the micro-flora of composts and beds, and on diseases and competitors of *Psalliota campestris*.

Published about the same time as the report is a new brochure on "Major Diseases and Competitors of the Cultivated White Mushroom" by Fred C. Atkins*. This is mainly a reprint of an earlier publication on major diseases[2], to which has now been added well-illustrated accounts of three competitors: brown plaster mould, *Papulaspora byssina*; truffle, *Pseudobalsamia microspora*; and white plaster mould, *Scopulariopsis fimicola*. Compost disease, *Myceliophthora* spp., mummy disease, and antagonism from *Fusarium* spp. are also described in the new publication. The whole is now an extremely useful compendium upon an otherwise little-known subject.

The Association also publishes the *M.G.A. Bulletin*, a quarterly journal. In addition to the work published in detail in the report of the Association, recent numbers of the *Bulletin* have included a plea by Mrs. M. H. Pinkerton for the cultivation of morels, *Morchella deliciosa* (No. 17, October 1949), and a preliminary note of a new mushroom disease (probably a species of *Acremonium*) by McG. Bulloch (No. 18, January 1950).

* "Major Diseases and Competitors of the Cultivated White Mushroom." By Fred C. Atkins. Pp. 23. (Yaxley, Peterborough: Mushroom Research Association, 1949.) 5*s*. net.

[1] *Nature*, **163**, 337 (1949).
[2] *Nature*, **163**, 796 (1949).

## BRITISH SCIENTIFIC INSTRUMENTS AT THE CANADIAN INTERNATIONAL TRADE FAIR, TORONTO

THE names and products of the British firms manufacturing scientific instruments have long been familiar to Canadians. In the early days of the development of industry and the establishment of new and enlargement of older universities in Canada, it was natural enough to call on Great Britain to furnish necessary scientific supplies. Although something like a tradition for British research instruments and pedagogical equipment grew up in the major universities it was inevitable that the increasing production of such articles in the United States should eventually provide a more convenient source. The absence in Canada of agents for the British firms, the unimpressive amount of publicity given to their products, and the intolerable delays in delivery, all contributed to the general swing to American products.

It is not proposed here to enumerate in detail the products of the various exhibitors at the recent International Trade Fair held at Toronto. The following were of particular interest: Scientific Instrument Manufacturers' Association, breathing apparatus, optical projection equipment, optical glass, fluid meters, balances, measuring apparatus; Allied Instrument Manufacturers, optometrical equipment; Baird and Tatlock (London), laboratory apparatus and furniture; Baker, microscopes; Barnet Ensign Ross, photographic materials and apparatus, binoculars, telescopes; Cambridge Instrument Co., Ltd., measuring apparatus for engineering, medical and chemical testing; Edwards (London), vacuum pumps and associated equipment; Electrothermal Engineering, laboratory heaters; Everett Edgcumbe, industrial electrical instruments; Hilger and Watts, spectrographs, polarimeters, microphotometers, surveying and drawing instruments, meteorological instruments, petrological microscopes; Kelvin and Hughes, industrial testing instruments; Pullin, electrical measuring instruments, small motors; Pye, instructional equipment in physics; Southern Instruments, transient recorders for engineering laboratories; Sperry, marine and aeronautical navigational instruments; Stanley, instruments of surveying, drawing and meteorology; Townson and Mercer, ovens, baths, stills for testing laboratories; Unicam, optical and X-ray goniometers, spectrophotometers; Watson, microscopes, telescopes; Wray, lenses, prisms, photographic equipment; Zeal, thermometers and hydrometers.

With a few exceptions the outward appearance and evident quality of the goods were excellent, and compare very favourably with the best American instruments.

The exhibition of electrical instruments was surprisingly meagre. Apart from a few pieces of apparatus of novel design and obvious utility in research, the whole series of electronic devices for routine testing and instruction was scarcely represented. One would have thought that such instruments as these, lending themselves readily to mass production, would have been the first to receive attention.

Optical and spectrographic equipment was fairly well represented, and a number of new and valuable research instruments were on view. Apparently no attempt was made to introduce X-ray equipment, apart from cameras and certain crystal analysers. Microscopes and apparatus for photomicrography were attractive. Measuring instruments of all kinds, laboratory furniture, high-vacuum equipment, medical and biological instruments, testing instruments of engineering and chemical laboratories, all had some or other new and attractive features. One could discover nowhere any significant attempt to supply routine instructional apparatus for school and college laboratories.

It would appear that instruments necessarily of limited demand were well represented, while those of more universal application were not shown. Unfortunately, the men in charge of the exhibits were in general not familiar with the details of the apparatus, in some cases not even able to identify certain instruments. Also, they were often unable to quote approximate prices and times of delivery. These criticisms, alas, can be justifiably applied all too often at exhibitions of scientific interest.

# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Soluble Carbohydrates of Fruit Plants

In the course of an investigation of the organic constituents of fruit plants, the soluble carbohydrates of shoots of apple, plum, etc., have been under investigation by the method of paper chromatography, using as solvents butanol–acetic acid–water (4 : 1 : 5)[1], butanol–ethanol–water (4 : 1 : 5)[2] and ethyl acetate–acetic acid–water (3 : 1 : 3)[3]. Whatman's No. 1 and No. 54 filter papers were employed. Spots on the paper chromatograms due to carbohydrates were revealed by using the reagents described by Partridge[1,3,4]. Examination of the papers after spraying was carried out both in ultra-violet light and daylight, the ultra-violet light being particularly useful in revealing weak spots after treatment with aniline-phthalic acid. For the detection of sorbitol a further reagent described below was employed.

The soluble carbohydrate fraction, isolated[5] from shoots (one season's growth) of a new clonal apple rootstock (*SV* 411) resistant to woolly aphis, collected from one of the nurseries at the Station in November 1948, yielded chromatograms which on spraying with the appropriate reagents showed spots corresponding in position to marker spots of fructose, glucose, sucrose and sorbitol, together with two spots, made visible by the ketose reagent, and having $R_F$ values corresponding to raffinose and stachyose. For the further identification of the two sugars, paper chromatograms on which a number of spots had been run simultaneously were cut up and the sugars extracted from the appropriate strips by the method of Dent[6]. The sugars were then hydrolysed with 0·2 per cent oxalic acid or with *N* sulphuric acid, and, after isolation, the hydrolysis products were chromatographed. At the same time, authentic samples of raffinose and of stachyose were chromatographed, eluted, hydrolysed and re-chromatographed by exactly the same procedure.

On comparison of the chromatographic pictures obtained from the hydrolysis products of the apple trisaccharide with those obtained from authentic raffinose, complete correspondence was seen to exist. In both cases, sulphuric acid hydrolysis yielded fructose, glucose and galactose. With oxalic acid small amounts of glucose and galactose were formed; but the main products in each case were fructose and a sugar ($R_F = 0{\cdot}08$ in butanol – acetic acid), which in view of the known hydrolysis products of raffinose may almost certainly be identified as melibiose. Lactose also has $R_F = 0{\cdot}08$ but is unlikely as a hydrolytic fragment.

A similar correspondence was obtained between the hydrolysis products of the apple tetrasaccharide and authentic stachyose, sulphuric acid again yielding fructose, glucose and galactose. Oxalic acid hydrolysis produced fructose and manninotriose ($R_F = 0{\cdot}04$ in butanol – acetic acid) as main products, an appreciable amount of melibiose and small amounts of galactose and glucose. In addition a spot ($R_F = 0{\cdot}09$) was observed slightly in advance of the melibiose spot. This spot, given both by authentic stachyose and the apple tetrasaccharide, has not yet been identified, but may arise from the splitting off of a glucose residue from manninotriose to give a disaccharide consisting of two galactose residues.

There seems little doubt that the two sugars under discussion are indeed raffinose and stachyose; but final confirmation requires the isolation of sufficient material for the determination of their physical constants. Experiments to this end are being undertaken.

Reviewing the results, the presence of fructose, glucose and sucrose is not surprising. The occurrence of a considerable amount of sorbitol in apple shoots has previously been demonstrated by Eaton[7]. It is of interest to recall Treboux's observation[8] that sections of leaves of Rosaceæ readily form starch when floated on a solution of sorbitol.

The presence of raffinose and stachyose in apple shoots has been overlooked hitherto, although judging from the appearance of the spots, these substances are present in amounts of the same order of magnitude as those of the three more familiar sugars. It is noteworthy that no free galactose was detected, in spite of a careful search, although the galactose residues were present in the two oligosaccharides. Pentoses also were absent. We have evidence, however, that they exist as components of certain of the glycosides present in apple shoots.

Precisely similar results were obtained using shoots of a plum stock (Myrobalan *B*) and Conference pear prunings, although raffinose and stachyose were absent from Conference pear leaves collected in the autumn just before leaf fall.

In view of the close similarity between the soluble carbohydrates of apple, plum and pear (all Rosaceæ), it seemed useful to make a comparison with the carbohydrates of a plant of a quite different botanical order. For this purpose wheat (Gramineæ) was selected, and the green stalks of Squarehead wheat, including the leaf blades and sheaths, but not the ear, were collected in July 1949, from one of the Station fields, just before yellowing began. A similar carbohydrate pattern was observed, but with the important difference that, in the position raffinose and stachyose would occupy, a series of at least five more or less overlapping spots were observed, indicating in this plant at this season a larger group of oligosaccharides than in dormant apple and plum rootstocks. It is clear that there is here an interesting field which requires full exploration.

We are indebted to Dr. R. Hill for the gift of the specimen of authentic stachyose used in these experiments.

*Note on the detection of sorbitol, mannitol and dulcitol on paper chromatograms.* Satisfactory results were obtained using an indicator solution containing boric acid prepared by dissolving bromocresol purple (40 mgm.) in 95 per cent methyl alcohol (100 ml.) containing boric acid (100 mgm.) and adding 1 per cent borax solution (7·5 ml.). The complex formed by the boric acid and the sugar alcohol causes a change in colour of the indicator, and when freshly sprayed the spots appear bright yellow against a blue background. On standing in air, the whole paper turns greenish-yellow, the spots then merging into the background. It is therefore necessary to mark the position of the spots immediately after spraying.

The fructose – boric acid complex also gives a similar spot, which, however, lies ahead of the spots due to sorbitol, mannitol and dulcitol. Under the conditions we have used, glucose and galactose give only very faint spots with the reagent. The $R_F$ values of sorbitol, mannitol and dulcitol lie closely together, being almost identical with that of glucose,

in the solvents mentioned above. We are continuing our search for a solvent which will separate them.

A. E. Bradfield
A. E. Flood

East Malling Research Station,
East Malling,
Kent.
April 20.

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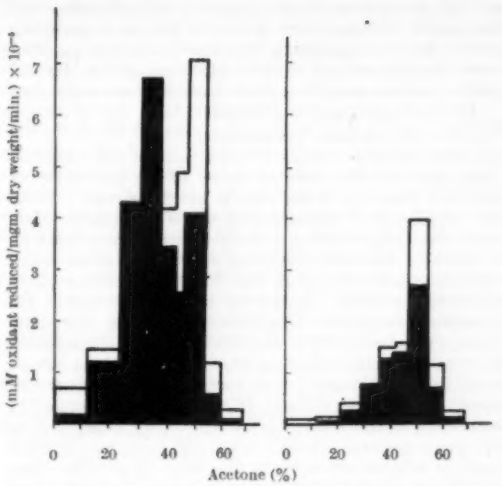
## Factors Concerned with the Oxidation of Reduced Coenzymes, and the Reduction of Cytochrome *c* in Pea Seedlings

In 1939, Lockhart[1] described a diaphorase I from the stems and roots of 12-day old pea and bean seedlings; this preparation, like Straub's heart diaphorase[2], catalysed the transfer of hydrogen from reduced coenzyme I to methylene blue. It was obtained as a suspension in phosphate buffer and was not purified further because it was extremely unstable, and no activity remained after two days storage. Soluble, stable preparations of a catalyst with certain properties similar to those of Lockhart's diaphorase have been obtained by the method described below. In this work, whole 6-day old pea seedlings were chosen because it is at this point of germination that the flavin level is highest[3]. The preparations so obtained, unlike Lockhart's, also showed catalytic activity in the transfer of hydrogen from reduced coenzyme II to methylene blue; diaphorase II has been found in the leaves of chickweed by Whatley[4]. In addition, these pea preparations will catalyse the reduction of ferricytochrome *c* by either reduced coenzyme I or reduced coenzyme II; these activities have not been reported previously in higher plants.

In this work, then, soluble protein fractions have been obtained from 6-day old pea seedlings which exhibit the following properties: (*a*) diaphorase activity between reduced coenzyme I and methylene blue (diaphorase I activity); (*b*) diaphorase activity between reduced coenzyme II and methylene blue (diaphorase II activity); (*c*) reductase activity between reduced coenzyme I and cytochrome *c* (cytochrome *c* reductase I activity); (*d*) reductase activity between reduced coenzyme II and cytochrome *c* (cytochrome *c* reductase II activity).




Distribution of activities (*a*) and (*b*) in acetone fractions. Blacked-in curve: test system for activities (*a*) and (*b*) as given in the table. Single-line curve: change in activity with the addition of 2 μgm. flavin-adenine dinucleotide and 2 μgm. flavin mononucleotide

The seedlings were extracted in 0·03*M* disodium hydrogen phosphate, dialysed against running water overnight, centrifuged, stored at − 10° C. for forty-eight hours, recentrifuged, and the supernatant fractionated with acetone at − 5° C. Nine protein fractions were obtained by the method of Askonas and Dixon[5] by fractionation with acetone between 0 and 68 per cent acetone. Activities (*a*) and (*c*) were measured by the rabbit muscle lactic dehydrogenase – coenzyme I system, (*b*) and (*d*) by the pig heart isocitric dehydrogenase[6] – coenzyme II system, (*a*) and (*b*) in evacuated Thunberg tubes at 38° C. with methylene blue in the hollow stopper, and (*c*) and (*d*) in the Beckmann spectrophotometer at 22° C. when cytochrome *c* was added after all the coenzyme had been reduced, and the reduction of cytochrome *c* followed at 550 mμ.

An examination of the histogram giving activities (*a*) and (*b*) in the nine fractions shows that diaphorases I and II have different distributions, although both activities are at their highest in the one fraction (fraction 7: 46–53 per cent acetone). Activities (*c*)

| Activity | (*a*) | | (*b*) | | (*c*) | | (*d*) | |
|---|---|---|---|---|---|---|---|---|
| Test system | 0·5 ml. rabbit muscle prep. 5 mgm./ml.; 0·3 ml. 0·5*M* lactate; 0·3 ml. *M* KCN; 1 mgm. Co I; 1·0 ml. 0·3*M* phosphate buffer, *p*H 7·4; 0·4 ml. 0·005*M* methylene blue. Total vol. 3·9 ml. | | 1·0 ml. pig heart prep. containing 0·17 ml. 0·5*M* citrate; 0·6 mgm. Co II; 1·0 ml. 0·3*M* phosphate buffer, *p*H 7·4; 0·4 ml. 0·005*M* methylene blue. Total vol. 3·9 ml. | | 0·3 ml. rabbit muscle prep. 5 mgm./ml.; 0·3 ml. *M* lactate; 0·65 mgm. Co I; 0·2 ml. 4·62 × $10^{-4}$*M* cytochrome; 1·0 ml. 0·3*M* phosphate buffer, *p*H 7·4. Total vol. 3·3 ml. | | 0·3 ml. pig heart prep. containing 0·05 ml. 0·5*M* citrate; 0·33 mgm. Co II; 1·3 ml. 0·3*M* phosphate buffer, *p*H 7·4; 0·2 ml. 4·62 × $10^{-4}$*M* cytochrome. Total vol. 3·3 ml. | |
| Preparation added | With flavin added | Without flavin | With flavin added | Without flavin | With flavin added | Without flavin | With flavin added | Without flavin |
| | (m*M*. oxidant/mgm. dry weight/min.) × $10^{-4}$ | | | | (m*M*. oxidant/mgm. dry weight/min. × $10^{-4}$) | | | |
| Acetone fraction 7 | 7·270 | 4·320 | 5·000 | 3·335 | 0·469 | 0·288 | 1·311 | 0·622 |
| Old yellow enzyme | — | 0·549 | 2·082 | 1·852 | 0·374 | 0·076 | 0·863 | 0·249 |
| Heart diaphorase I | — | 25·4 | — | 0·716 | 0·19 | 0·026 | 0·944 | 0·195 |
| Test system alone | 0·286 | 0·302 | 1·000 | 0·646 | 0·282 | 0·096 | 0·770 | 0·185 |

and ($d$) are also at their highest in this fraction and the results obtained are given in the accompanying table. As a comparison, the activities of a purified heart diaphorase and a crude preparation of the old yellow enzyme are given also. Activities are expressed as $\frac{1}{t} \times \frac{\text{amount oxidant reduced}}{\text{dry weight preparation}}$; where $t$ is the time for sensibly complete reduction of the oxidant.

In spite of the concentration of all activities in this one fraction, some trends are apparent. With the coenzyme I experiments it is noticeable that some fractions obtained with lower concentrations of acetone contain relatively more diaphorase than reductase activity, and the higher fractions more reductase activity. This may be evidence either for a separate catalyst acting between reduced coenzyme I and cytochrome $c$, or alternatively for the appearance of another factor in the later fractions which could link diaphorase I to cytochrome $c$. The distributions of the diaphorase II and the reductase II activities in the fractions, on the other hand, follow the same general pattern, although here, too, there is more reductase activity in the later fractions. This similarity of distribution may mean that the two activities are present in the same protein, or simply that there is an additional reductase factor with solubility properties similar to the diaphorase.

The addition of a mixture of flavin–adenine dinucleotide and flavin mononucleotide (2 $\gamma$gm. of each) has been found to stimulate many of these fractions (see histogram), due possibly to the partial dissociation and removal of flavin during the acetone treatment. A preparation from an alcohol fractionation containing high diaphorase I activity has been 'split' by using ammonium sulphate and hydrochloric acid at − 5° C., and the protein precipitate from this separation has been partially reactivated by flavin mononucleotide.

I am grateful to Dr. R. Hill and Dr. A. R. Trim for much helpful advice and criticism, and to the Commissioners for the Exhibition of 1851 for a scholarship.

DAPHNE C. DAVISON

Biochemical Laboratory,
Cambridge.
March 30.

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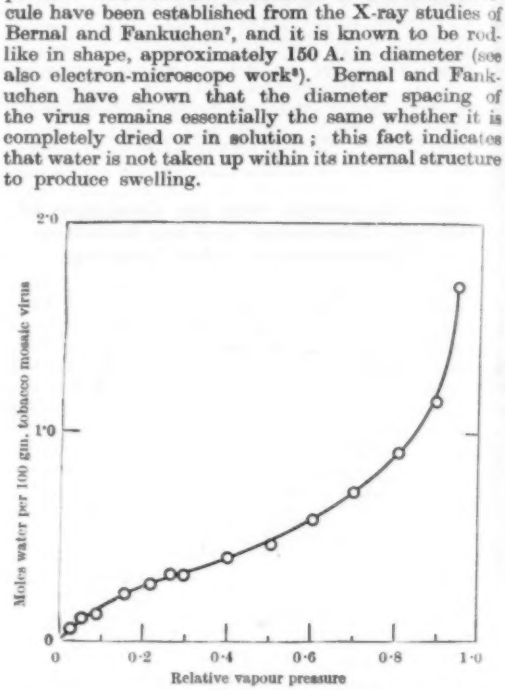
## Sorption of Water Vapour by Tobacco Mosaic Virus

THERE are abundant data in the literature indicating the applicability of the Brunauer, Emmett and Teller multilayer theory of site sorption to proteins and polyamides[1,2]. $V_m$, the first monolayer calculated by such treatment of the sorption data involving inert gases, has been shown to be related to the available surface area[3]. More recently, Benson *et al.*[4] have determined $V_m$ for several proteins from the nitrogen and oxygen sorption systems, and have shown that the values are much lower than the 'monolayer' determined from water sorption on similar proteins[2]. Their results are consistent with the physical size of their preparations as revealed by the electron microscope. Accordingly, the sorption of water molecules by protein is considered to involve a different process from the surface sorption of inert gases. Pauling[5], Robinson[6] and others have related the number of sites available for water sorption to the hydrophilic side-group linkages not only on the surface but also in the interior of the protein molecule.

Tobacco mosaic virus, however, presents a different picture. The external dimensions of the virus molecule have been established from the X-ray studies of Bernal and Fankuchen[7], and it is known to be rod-like in shape, approximately 150 A. in diameter (see also electron-microscope work[8]). Bernal and Fankuchen have shown that the diameter spacing of the virus remains essentially the same whether it is completely dried or in solution; this fact indicates that water is not taken up within its internal structure to produce swelling.




Water-vapour adsorption isotherm for tobacco mosaic virus at 25°

We have examined the uptake of water vapour by tobacco mosaic virus. The accompanying graph shows the 25° C. adsorption isotherm obtained by equilibrating the dry virus over a series of sulphuric acid solutions, according to the method of Hauser and McLaren[9]. (The virus was obtained by courtesy of Dr. G. Oster. After drying over phosphorus pentoxide at 5°, it was still active.) As expected, the isotherm is represented by a sigmoid curve, found typically for proteins and other polypeptides[2,10]. $V_m$, obtained from a Brunauer–Emmett–Teller plot of the data, is found to be 0·30 moles of water per 100 gm. of the virus. Using 10·6 A.$^2$ as the area occupied by a water molecule[11], $V_m$ corresponds to a surface area of $1{\cdot}92 \times 10^3$ cm.$^2$ per 100 gm. of virus.

The partial specific volume[6] of the dried virus is 0·73. The diameter of the virus rod has been determined as 150 A. for phosphorus pentoxide–vacuum-dried and 152 A. for air-dried virus. Using the value of 150 A. and neglecting the negligible surface presented by the ends of the rods, 100 gm. of the virus possesses a geometric surface area of $1{\cdot}95 \times 10^3$ cm.$^2$, in excellent agreement with the area available for the water-sorption monolayer.

If these results are not fortuitous, it would appear that the Brunauer–Emmett–Teller theory can be applied to this system, and that the first sorbed

water molecules are not primarily adsorbed into the interior as is the case with other proteins.

BERNARD KATCHMAN
JANICE CUTLER
A. D. MCLAREN

Institute of Polymer Research,
Polytechnic Institute of Brooklyn,
New York.
April 10.

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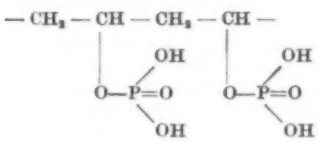
## Polyvinylphosphate Contractile Systems

Riseman and Kirkwood[1] recently suggested that the relaxation of muscle may be attributed to its stretching by the electrostatic repulsion of the ionized groups carried by the phosphorylated myosin molecules. During the contraction, the phosphate groups are split off, and the macromolecules coil up by Brownian movement.

In continuation of previous researches on mechanochemical systems[2,3,4], we found that synthetic polyphosphate systems indeed exhibit a high contractility. Polyvinylphosphate, readily obtained by the phosphorylation of polyvinyl alcohol, served as a simple model for the above theory.



Fibres of high-molecular polyvinyl alcohol, 0·15 mm. thick, containing 10–15 per cent moisture, were heated, while stretched, in sealed ampoules, for 24 hr. at 160° C. The cross-linked, water-insoluble fibres were phosphorylated by phosphorus pentoxide and phosphoric acid[5], a procedure which did not cause too extensive a degradation of the polymeric fibre. The reaction was stopped when a sample of the partly phosphorylated material, removed from the phosphorylating bath and thoroughly washed with water, exhibited strong contractility in concentrated hydrochloric acid. The amount of phosphorus bound by the fibre, after twenty-four hours treatment in the phosphorylating bath, at room temperature, was found to be 12 per cent; that is, about 25 per cent of the vinyl alcohol units had reacted. The method of Sumner[6,7] was employed for the analysis of the phosphorus. After four days treatment in the phosphorylating bath, the amount of phosphorus bound by the fibre increased to 18·9 per cent, that is, about half of the vinyl alcohol units had reacted. This degree of phosphorylation very distinctly weakened the polyphosphate fibre.

At neutral *p*H the free phosphate groups are ionized and the fibre is highly swollen and elongated. When the fibre is dipped into concentrated hydrochloric acid to suppress the ionization of the phosphate groups, it contracts violently in a fraction of a second to about one-half of its length and one-third of its thickness in the swollen state. The neutralization of the charged groups, in our experiments, is, in a sense, analogous to the enzymatic splitting off of the phosphate groups in the muscle, according to the scheme postulated by Riseman and Kirkwood[1]. When the fibre is returned into distilled water, or into dilute alkali to neutralize the acidic groups, it expands rapidly to its original length; the process may be repeated many times. The speed of dilation and of contraction is many times greater than that observed in systems previously investigated.

Various systems, capable of better mechanical performance, are now being investigated.

A. KATCHALSKY
H. EISENBERG

Department of Polymer Research,
Weizmann Institute of Science,
Rehovoth, Israel.
April 12.

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## Salicylhydroxamic Acid as an Antitubercular Agent

SOME derivatives of salicylic acid possess antitubercular properties, the most important of such substances being the well-known *p*-aminosalicylic acid used by Lehmann[1]. Nevertheless, numerous investigations seem to indicate that most of the antitubercular compounds contain amino-groups. Hydroxamic acids can be used as reagents to introduce primary amino-groups into an aromatic nucleus, as found by Turski[2]. I have recently confirmed this[3] by using diacetyl-aceto-hydroxamic acid (O N N-triacetylhydroxylamine) as an aminating agent. Upon the assumption that this compound would combine the curative properties of some salicylic acid derivatives with those of amino-compounds, the hydroxamic acid group being in a way a potential amino-group, it seemed worth while to test the value of salicylhydroxamic acid as an antitubercular agent.

Salicylhydroxamic acid was prepared according to Jeanrenaud[4] by the action of an alkaline solution of hydroxylamine on the sodium salt of methyl salicylate in aqueous medium. Salicylhydroxamic acid prepared in this way contains a certain amount of salicylic acid, but it can be purified by crystallization from acetic acid; the melting point was 168° on slow heating and 176–178° on quick heating (Jeanrenaud gives 169°).

Because salicylhydroxamic acid is dissolved with difficulty in water, the monosodium salt of the acid was then prepared by acting with 1 mol. of sodium bicarbonate (concentrated solution in water) on 1 mol. of salicylhydroxamic acid (concentrated solution in alcohol). The combined solution was filtered and con-

centrated on a water-bath to obtain the crystalline plates of the sodium salt ($C_7H_6O_3NNa$ requires N, 8·00; Na, 13·14; found: N, 7·97; Na, 13·27 per cent). The salt is readily soluble in water, giving a 0·1 *N* solution of *p*H 7·7.

Experiments *in vitro* in Youmans medium against *Mycobacterium tuberculosis*, saprophytic mycobacteria, Gram-negative and Gram-positive bacteria as compared with the action of *p*-aminosalicylic acid were carried out by Prof. S. Slopek, of the Institute of Microbiology, Silesian Medical Academy, Bytom. The results of bacteriostatic concentrations of the two substances (mgm. per 100 ml.) are shown in Table 1.

Table 1

| | *p*-Aminosalicylic acid (sodium salt) | Salicylhydroxamic acid (sodium salt) |
|---|---|---|
| *Mycobacterium tuberculosis* ($H_{37}Rv$ strain) | 1·0 | 1·0 |
| Saprophytic mycobacteria (6 strains) | 10·0 | 5·0 |
| *E. coli* | 500·0 | 25·0 |
| *Ps. aeruginosa* | 500·0 | 50·0 |
| *Staph. pyogenes* | 500·0 | 100·0 |
| *Strept. fæcalis* | 500·0 | 250·0 |
| *Corynebact. diphtheriæ* | 500·0 | 250·0 |

Experiments *in vivo* were also carried out by Prof. S. Slopek, using white mice inoculated (intravenous) with 0·1 mgm. of *Mycobacterium tuberculosis* ($H_{37}Rv$ strain). The results are shown in Table 2.

Table 2

| | Number of animals | Daily dose (mgm. per mouse) | Mortality | Average tubere. index | Average survival time (days) |
|---|---|---|---|---|---|
| *p*-Aminosalicylic acid, sodium salt | 50 | 10 | 50 | 58 | 23·1 |
| Salicylhydroxamic acid, sodium salt | 50 | 5 | 62 | 66 | 22·1 |
| Control | 50 | — | 100 | 100 | 20·1 |

All animals were treated for twenty-four days. When the experiment was terminated, all survivors were killed, and the extent of tuberculous involvement was noted and rated.

In another series of experiments, Dr. J. Venulet, of the Institute of Pharmacology, Medical Academy, Warsaw, determined the therapeutic index of the sodium salt of salicylhydroxamic acid on white mice. The minimum of lethal dose was found to be about twelve times the curative dose.

Further experiments, including clinical trial, are being carried out. Also some new derivatives of salicylhydroxamic acid are being prepared. They will be used for further experiments *in vitro* and *in vivo*.

T. Urbański

Department of Chemistry,
Institute of Technology,
Warsaw,
and
Polish Antitubercular Institute,
Warsaw.
Oct. 12.

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## Metaphosphate in the Excreta of the Wax Moth, *Galleria mellonella*

In the course of investigations on the phosphorus metabolism of the wax moth, *Galleria mellonella*, it was found that there is as much as 2–4 per cent phosphorus in the excreta of the larvæ, of which only a small proportion is inorganic orthophosphate. The greater part, 60–70 per cent, is a labile phosphorus compound which is converted almost entirely to orthophosphate following 7 minutes hydrolysis at 100° C. in 1 *N* hydrochloric acid. As analysis of the honeycomb showed that it contained only orthophosphate, we had ground for supposing that the readily hydrolysable phosphorus in the excreta is formed in the larval body[1].

In further experiments we have studied the chemical nature and properties of this labile phosphorus compound, so unusual for the excreta. The compound was water- and acid-soluble and belonged to the barium-insoluble fraction. It could be precipitated with lead nitrate at *p*H 2 according to the procedure of Mann[2]; it precipitated protein from serum and gave a positive metachromatic reaction with toluidine blue[3,4] both directly in the aqueous extract from the excreta and after precipitation of the compound with lead nitrate.

We have not been able to carry out an elementary analysis of the precipitated compound so far because of difficulty connected with the separation of the labile phosphorus from uric acid which is present in the excreta and is also precipitated with lead and barium salts. From the above results it seems probable, however, that the phosphorus compound which we found in the excreta of *Galleria mellonella* is metaphosphate. After 7 minutes acid hydrolysis it is transformed into orthophosphate, and thereafter the reactions mentioned above become negative.

The possibility that some micro-organisms from the larval gut may be partly responsible for the formation of metaphosphate cannot be excluded. As to this, there seems, however, to be considerable uncertainty. If such micro-organisms in fact play some part in this process, then it is only to a limited extent, since we found the labile phosphorus compound in the excreta of larvæ which had been starved for a considerable period. The relative amount of readily hydrolysable phosphorus was in this instance even greater, reaching 90 per cent of the total phosphorus. Further, in the starving larvæ we found a phosphorus fraction hydrolysable in acid in 7 minutes in the urine collected directly from the Malpighian tubes, and in the imago we found it in the meconium.

Our results show that the metaphosphate is formed in considerable quantities in the body of *Galleria*. The larvæ retain only some 15 per cent of the phosphorus consumed with their food; 85 per cent of it is excreted, the greater part of which probably undergoes conversion first into metaphosphate.

In the excreta of several other insects which we analysed (*Dixippus*, *Ephestia*, *Bombyx mori*) phosphorus was present exclusively in the form of orthophosphate. The only exception was *Achræa grisella*, a moth which, like *Galleria*, feeds on honeycomb. The excreta of *Achræa* contained about 1 per cent labile phosphorus, the amount of orthophosphate being only 0·2 per cent.

As yet, we do not know what significance to ascribe to these relatively large amounts of metaphosphate; the fact that this compound appears only

in the excreta of *Galleria mellonella* and *Achræa grisella* suggests a connexion with the unique ability of these insects to digest and assimilate wax.

A detailed report of this work will be published elsewhere.

STELLA NIEMIERKO
W. NIEMIERKO

Department of Biochemistry,
Nencki Institute of Experimental Biology,
Lodz.
March 31.

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## Identification of *p*-Cresol as a Toxin in Œstrogen Concentrates from Sheep Urine

DURING a study in this laboratory of the urinary excretion of œstrogens by sheep, the final œstrogen concentrates injected into mice often proved so toxic that bio-assay by the spayed mouse vaginal smear method was impossible. This toxicity was observed in concentrates from pregnant, non-pregnant and spayed ewes. Typical symptoms of lethargy and panting appeared within ten minutes in extreme cases, followed by death in less than two hours. Post-mortem examination usually showed gaseous distension of the entire alimentary tract. When symptoms were less severe, the animals usually recovered slowly over a period of several days.

To detect œstrogenic activity it was necessary to inject the extract from a large volume of sheep urine, an injection of 0·1 ml. of the final oily extract corresponding to as much as 70 ml. of urine. Since the usual extraction methods for œstrogen, including that used[1], would be expected to concentrate other phenolic material also, it seemed likely that toxicity was due to accumulation of simple phenols known to occur in urines. Portions of the toxic concentrates were therefore subjected to steam distillation. The distillates produced the typical toxic symptoms, whereas the residue could be used safely for bio-assay.

The steam distillates from 17·3 litres of ewe pregnancy urine gave on ether extraction 5·1 gm. of phenolic material. Fractionation at atmospheric pressure yielded only one fraction (4·4 gm., b.p. 196–99°), which soon formed crystals (m.p. about 23°, deliquescent). Physical properties were consistent with those of *p*-cresol, and this was further characterized by conversion to the *p*-toluenesulphonate (m.p. 67°, reported m.p. 70° [2]), and to *p*-methyl phenoxyacetic acid (m.p. 135–36°, reported m.p. 136° [3]). The corresponding derivatives prepared from authentic *p*-cresol had the same melting points, and gave no depression of melting point on admixture with the derivatives from the urinary phenol. A small amount of residue in the distillation flask was recovered as a *p*-cresol derivative. Twenty-three litres of urine from another pregnant ewe gave 9·9 gm. of crude phenols, and 16·4 litres from a non-pregnant ewe gave 5·9 gm. of phenols. These on distillation gave only a *p*-cresol fraction, characterized as previously.

Further evidence identifying *p*-cresol as the toxic substance is that injection of pure *p*-cresol into mice produced the typical toxic symptoms.

Campbell and Hey[4] have reviewed the literature on the occurrence of *p*-cresol and other phenols in the urines of animals and humans. *p*-Cresol occurs in most urines, usually with several other phenols; but the concentration is usually low (see also Porteous and Williams[5]). There appears to be no record of the examination of sheep urine for phenols. The urine of stallions gave 0·055 per cent of *p*-cresol[4], while in urine of the pregnant and non-pregnant ewe we find a comparable value of 0·03 per cent. The absence of appreciable amounts of other phenols in sheep urine is of interest.

We have found it most convenient to remove the toxin from the concentrates by carrying out the steam distillation at the stage when the alkaline extract containing the œstrogens had been acidified. To obtain rapid and consistent removal of toxin, it was necessary to saturate the acid solution with sodium chloride before distillation. In experiments in which œstrogens in the form of human pregnancy urine were added to sheep urine, no loss of œstrogenic activity was observed when the steam distillation stage was included. Friedgood *et al.*[6] showed that pure œstrone, œstradiol and œstriol are not steam-volatile, and can be recovered quantitatively. After introducing this modification, it has been possible to complete assays with extracts which previously would have killed the test animals.

E. P. WHITE
O. K. SEWELL
E. G. BASSETT

Ruakura Animal Research Station,
Department of Agriculture,
Hamilton,
New Zealand.
Feb. 14.

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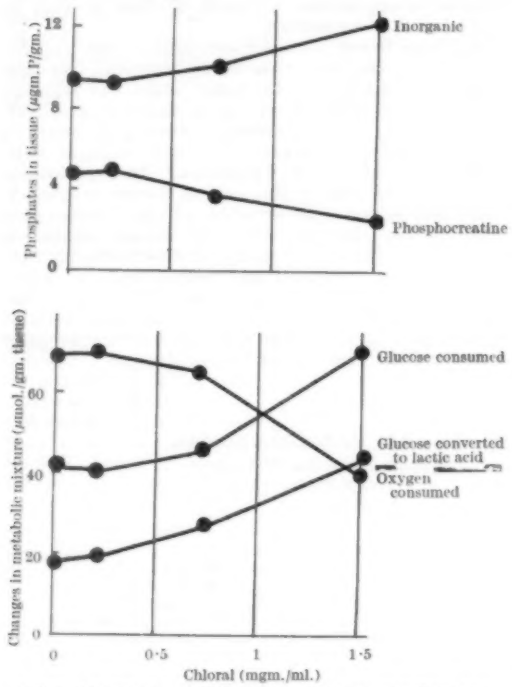
## Narcotics and the Phosphates of Brain

IN brain, as in other organs, phosphates form an important link between function and the metabolism which supports function[1]. The levels of inorganic and esterified phosphates in brain *in vivo* have been examined previously; but there is little information on the levels of phosphates during *in vitro* metabolism[2], possibly because of the reports of rapid post-mortem changes in these constituents[3]. We have, however, found that during metabolism *in vitro* the concentration of inorganic phosphate and of phosphocreatine can be restored to stable levels, which depend on metabolic conditions and which can approximate closely to those normal to the brain *in vivo*. Determinations of both phosphates and creatine have been made, following separations by calcium salts and alcohol[4]. Inorganic phosphate has been determined according to Lowry and Lopez[5]. The sum of inorganic phosphate, and phosphates with the lability of creatine phosphate, has been determined by the method of Fiske and SubbaRow[6].

It has therefore been possible to compare the actions of drugs on phosphates during their actions *in vivo* and *in vitro*, and we report now some conclusions with respect to the action of narcotics. These substances inhibit respiration *in vivo*[7] and also *in vitro*[8], and suggestions have been made that depression of cerebral respiration is the primary action of

narcotics *in vivo*. However, we find that the changes in phosphates are in the opposite sense in two cases; the accompanying graph gives our *in vitro* results, when we find that with fall in respiration the concentration of creatine phosphate also falls, while that of inorganic phosphate rises. *In vivo*, increase in phosphocreatine and decrease in inorganic phosphate have been reported[4,9].




Action of chloral on metabolism *in vitro*. Guinea pig cortex slices of about 100 mgm. were shaken at 37° in physiological salines buffered with glycylglycine, and containing the concentrations of chloral indicated. Respiration was followed manometrically for 75 min., and at the end of the experiment the slices were drained and their content of inorganic phosphate and of phosphocreatine determined. Glucose and lactic acid were determined in the solution after metabolism. Similar changes have been found to follow the action of ethyl butyl barbituric acid

The results *in vitro* are consistent with the primary action of narcotics at a stage in respiratory metabolism, associated with the decrease in phosphorylation already observed in brain homogenates with another narcotic[10] and which we have also found to occur with chloral. It can be understood that the changed concentrations of phosphates and also the increase in lactic acid[11] should follow from this[12]. We have found these changes *in vitro* to occur at concentrations of chloral higher than those necessary for narcosis *in vivo*[11]. The significance of the results *in vivo* can now be assessed more clearly, and it is seen that the accumulation of energy-rich phosphates indicates a primary depression of function with which the lowered inorganic phosphate and decreased lactic acid are also associated and which, by the mechanism referred to previously[12,1], can lead to lowered respiration.

Chemical analyses, both *in vivo* and *in vitro*, have concerned relatively large portions of brain, and it remains possible that the narcotic *in vivo* may exert a primary biochemical effect on a small and more sensitive part of the brain, by the mechanisms observed to be operative in brain as a whole at higher concentrations of the narcotic. In this case one must suppose such inhibitions to lead to a depression of function in the bulk of the brain. A primary depression of electrical reactivity *in vivo*, with metabolic sequelæ, also remains possible.

L. Buchel
(British Council Bursar)
H. McIlwain
Biochemical Laboratories,
Institute of Psychiatry,
(British Post-Graduate Medical Federation,
University of London),
Maudsley Hospital,
London, S.E.5.
April 14.

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## Vitamin $B_{12}$ Assay in Body Fluids

Vitamin $B_{12}$ is required as an essential growth factor by *Euglena gracilis* variant *bacillaris*[1]. No other substance has been found to stimulate the growth of this alga in the absence of $B_{12}$.

Assays of crystalline $B_{12}$ (obtained by courtesy of Glaxo Laboratories) and liver extracts have been carried out, using a modification of the technique described by Hutner. About 1 μμgm./ml. is the least amount stimulating growth, and, because of the greater sensitivity of this assay method over the *Lactobacillus* methods, it was considered more suitable for attempting the estimation of body fluid concentrations of vitamin $B_{12}$.

Normal human serum, human urine (unless dilute) and horse serum were found to stimulate growth of the *Euglena* when added to a basal medium containing no $B_{12}$. It is not practicable to detect less than the equivalent of about 10 μμgm./ml. with the technique used, because of growth inhibition and coagulation of serum on heating if these fluids are more concentrated than in a final dilution of 1/8 or 1/10. The amount of growth obtained with sera was found to vary according to the degree of heating before inoculation. Preliminary work was done with dilutions of sera in distilled water heated at 70° C. for half an hour and added to the basal medium, and values equivalent to 20–350 μμgm./ml. with a mean of 185 μμgm./ml. were found in sera from forty patients with a variety of conditions. Twelve similar sera, heated at 100° C. for a half to one hour, were much more active, giving the equivalent of 350–750 μμgm./ml. with a mean of 490 μμgm./ml.,

and some assays of other sera have suggested activity equivalent to more than 1,000 μμgm./ml. Sera, however, heated at 100° C. for one and a half to two hours were less active than after one hour, while heating at 100° C. at about *p*H 10 for half an hour reduced the activity of twelve sera by from 60 to 95 per cent. As an example of the difference in growth activity after heating, a batch of horse serum heated for half an hour at 56° C. gave growth equivalent to 13 μμgm./ml., at 70° C. to 70 μμgm./ml. and at 100° C. to 220 μμgm./ml.

Heating of urine at 70° C. and cerebro-spinal fluid at 100° C. has not significantly altered assay results. The activity of the few cerebro-spinal fluids so far tested has been from nil to 16 μμgm./ml.—a very low result compared with sera—and that of urines has been from nil to 200 μμgm./ml.

Sera in the lowest practicable dilutions (heated at 70° C.) from four cases of pernicious anæmia, and urine from one, did not stimulate growth of the *Euglena*. (Urines from the other cases were not available for testing.) Two of these sera were later heated at 100° C. and by autoclaving, and some activity was found, but this was much less than with the normal sera so far assayed.

Sera from two cases of pernicious anæmia after intramuscular injection of $B_{12}$ showed very marked activity which has gradually declined in serial assays continued over several weeks after injection. Heating of these sera also was necessary for full activity, suggesting that $B_{12}$ circulates in a microbiologically inactive (an altered or combined) form after injection, as it appears to do when absorbed normally from the intestine. Two and a half hours after an injection, however, as much as 25 per cent of the total activity in one serum could be detected without heating.

This modification of Hutner's technique would therefore appear to detect $B_{12}$ in body fluids as well as in liver extracts, particularly in view of the fact that the activity of serum is increased after parenteral injection of $B_{12}$. The possibility of some substance other than $B_{12}$ present in body fluids stimulating or potentiating growth cannot yet be excluded; but the relatively poor growth with the pernicious anæmia sera so far tested, and the reduction of activity of normal serum at 100° C. at *p*H 10, suggest that the assay is specific.

G. I. M. Ross

Department of Bacteriology,
Postgraduate Medical School of London,
London, W.12.
April 19.

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## Conversion of Hydrastine into Berberine, and an Instance of the Asymmetrical Quaternization of a Tertiary Base

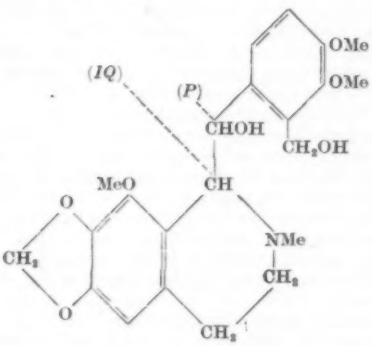
THE molecule of narcotine contains two asymmetric carbon atoms, *IQ* in the *iso*quinoline nucleus and *P* in the phthalide nucleus. The action of strong bases under suitable conditions racemizes *P* but leaves *IQ* unchanged[1]. Thus natural l-α-narcotine is partly transformed into l-β-narcotine; $-IQ, -P \rightleftharpoons -IQ, +P$.

Reduction of l-α-narcotine with lithium aluminium hydride affords a glycol (I), melting point 134°, $[\alpha]_D$ −10·4° in *N*/10 hydrochloric acid. This base forms a characteristic methiodide and an O-diacetyl-derivative, melting point 165–6° (decomp.). l-β-Narcotine, on reduction under similar conditions, gives an oily glycol (I) which yields a crystalline methiodide.

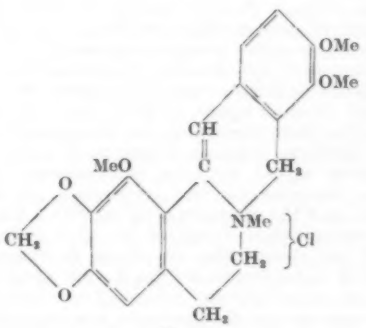
There can be no doubt that these stereoisomeric glycols correspond in configuration to the narcotines from which they were prepared. Treatment of either of them with thionyl chloride results in the formation of one and the same quaternary salt (II), in which neither of the asymmetric carbon atoms has survived. However, the salt (II) is optically active, and hence the ring-closure to the quaternary ammonium salt occurs asymmetrically under the influence of the environment of the *IQ* carbon, which is the constant factor.

The *P* carbon, in opposite configuration in the two glycols, evidently exerts no directive action by reason of its own asymmetric character, though it may well be decisive as a member of the *IQ* group. In other language, the position of the whole *sec.*-alcoholic group, but not of the hydroxyl in that group, decides the direction of quaternization. This accords with theoretical expectations.

After the asymmetric nitrogen has been set up, the elimination of water destroys *IQ* and *P* together as asymmetric centres.




I




II

Similarly, natural hydrastine (l-β-hydrastine) was reduced by lithium aluminium hydride to a glycol, $C_{21}H_{25}O_6N$, melting point 143–44°.

Treatment with thionyl chloride then gave dihydroanhydroberberine methochloride (des-methoxy—II). On heating at 160–170° under diminished pressure, dihydroanhydroberberine was produced and identified as hydrochloride with a sample prepared from

berberine[2]. The final oxidation to berberine is easily accomplished. It is of interest to recall that an assumed structural relation between the congeneric alkaloids, hydrastine and berberine led to a revision of the formula for berberine[3].

R. Mirza
R. Robinson

Dyson Perrins Laboratory,
University, Oxford.
June 27.

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## Fluorescence of Amino-Acids, Peptides and Amines on Filter Paper

The fluorescence of amino-acids and peptides on dry filter paper[1] is of great value for locating these substances after paper chromatography, and has been found useful in quantitative work[2] since it avoids destructive treatment with reagents such as ninhydrin. It also enables substances to be eluted for further investigations from sheets of chromatograms where gross irregularity of solvent flow renders the use of marker strips[3] inaccurate as guides for cutting. Unfortunately, marked variations in fluorescence are often observed when identical chromatograms are run on sheets of No. 4 Whatman paper from different packets of papers or even on adjacent sheets from the same packet[4], and batches of papers are occasionally encountered on which no fluorescence at all can be observed at normal nitrogen-levels. As Phillips[1], quoting De Ment[5], considered fluorescence of amino-acids on paper to be due to excitation of the acids themselves by ultra-violet light, it seemed possible that some impurity present in 'bad' fluorescent papers might therefore be quenching fluorescence. Sheets from a particularly bad batch of No. 4 Whatman paper could not be improved, however, by washing with water, dilute sodium hydroxide, hydrochloric acid or with solutions of 8-hydroxyquinoline or dithizone.

When crystals of some twenty amino-acids were examined in ultra-violet light from a lamp known to excite fluorescence on chromatograms, only tryptophane, histidine and citrulline were markedly fluorescent, the feeble fluorescence of the remainder suggesting that their intrinsic activity was unlikely to account for their fluorescence on dry chromatograms. When, however, aqueous solutions of these amino-acids were mixed with an experimental cellulose powder (intended for the preparation of cellulose columns) and the mixtures dried at 80° C., the resulting powders, when examined by ultra-violet light, showed an intense blue or purple fluorescence. A control of cellulose powder dried with water instead of amino-acid solution remained a dull purple. Similar results were obtained with a number of simple peptides and amines. The results with amines showed that the amino-group alone was necessary for reaction. Of several cellulose powders tested, only one failed to produce fluorescence with amino-compounds. This powder had not been modified by any acid treatment in the course of its preparation, whereas all the reactive powders had been treated either with nitric or hydrochloric acid, and gave a strong yellow colour when heated with dilute sodium hydroxide solution, a reaction typical of modified cellulose[6].

Johansen and Nickerson[7] have suggested that a reaction analogous to the 'browning reaction' between amino-acids and reducing sugars interferes with quantitative paper chromatography of amino-acids, while Graham, Hsu and McGinnis[8] have recently shown that some fifteen amino-acids react with glucose on autoclaving to produce fluorescent substances, the glucose acting as a source of aldehydic groups. It is suggested, therefore, that the fluorescence of amino-acids, peptides and amines on filter paper arises through reaction with aldehydic groups derived from modified or short-chain celluloses present in the paper. This would account for the failure to recover a 'bad' paper by washing techniques, such a paper, in fact, being more pure than one on which fluorescence was strong. Since this work was done, a note by Patton, Foreman and Wilson[9] has directed attention to the essential part played by cellulose in the production of fluorescence on paper chromatograms. The reaction between cellulose powders and amino-compounds may be of use in detecting these substances after partition chromatography on cellulose columns as, by heating the column, it should be possible to locate the separated amino-compounds as fluorescent bands. The reaction may also have some bearing on the apparent loss of amino-nitrogen occurring during paper chromatography[10,11].

I wish to thank the paper manufacturers, Messrs. W. and R. Balston, Ltd., and their agents, Messrs. H. Reeve Angel and Co., Ltd., for their interest and help in these investigations, and for their gift of samples of various experimental cellulose powders.

A. J. Wolwod

Wellcome Research Laboratories,
Langley Court,
Beckenham, Kent.
April 19.

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## A Reversed-Phase Partition Chromatogram using Chlorinated Rubber

Until quite recently, the substances used for supporting the stationary phase in partition chromatography have held the more polar solvent preferentially. Chromatograms of this type have been very satisfactory for the separation of substances with predominantly water-soluble character; but several workers have pointed out that full advantage cannot be taken of small differences in partition coefficients if these are in the range which gives $R$ values[1] much above 0·5. In the case of compounds such as the higher fatty acids, where the partition coefficients greatly favour the non-aqueous phase, these ideal conditions cannot be realized, and it has been suggested that a system in which the phases are reversed

would lead to useful results. Attempts have been made by Boscott[2], using cellulose acetate, and by Boldingh[3], using rubber powder, to hold the less polar phase on the inert support, and recently Howard and Martin[4] have described the use of kieselguhr, impregnated with silane, for a reversed-phase partition column.

However, all these methods involve difficulty in the preparation of a homogeneous support. We have now developed a reversed-phase chromatogram using a commercial chlorinated rubber ('Alloprene', I.C.I., Ltd.; extra high viscosity grade *E*) for the separation of the N-2 : 4-dinitrophenyl derivatives[5] of amino-acids by partition between butanol and aqueous buffer. Chlorinated rubber is a light cream-coloured, free-flowing powder, soluble in non-polar organic solvents (for example, benzene) but capable of retaining alcohols such as butanol in a partition chromatogram. The chlorinated rubber (150-200 mesh/in.) was prepared by shaking it with a suspension of butanol (4 ml. per 10 gm. of chlorinated rubber) in 0·2 *M* citrate – phosphate buffer previously saturated with butanol. The slurry thus obtained was used for packing the columns by filtering under slightly reduced pressure in the usual way. The *R* values of a number of dinitrophenyl amino-acids using butanol-saturated buffer of varying *p*H as the flowing solvent are given in the accompanying table. It is seen that the order of *R* values obtained is with a few exceptions the reverse of those obtained by Sanger[5] using silica gel columns and by Partridge and Davis[6] using buffered filter paper.

*R*-Values of Dinitrophenyl Amino-Acids on Chlorinated Rubber Compared with *Rf*-Values on Buffered Filter Paper

| Supporting substance | Allo-prene | Allo-prene | Allo-prene | Filter paper |
|---|---|---|---|---|
| Solvent | *n*-butanol | *n*-butanol | *n*-butanol | *Tert.*-Amyl alcohol |
| *p*H of buffer | *p*H 3 | *p*H 4 | *p*H 5 | *p*H 6·75 |
| ε-Dinitrophenyl-lysine | 1·15 | — | — | 0·40 |
| Dinitrophenyl-asparagine | 0·83 | — | — | 0·23 |
| " -serine | 0·61 | 1·14 | — | 0·26 |
| " -aspartic acid | 0·40 | 0·96 | — | 0·03 |
| " -glycine | 0·33 | 0·79 | — | 0·27 |
| " -alanine | 0·18 | 0·58 | — | 0·43 |
| " -proline | 0·17 | 0·54 | 1·14 | 0·51 |
| " -valine | 0·10 | 0·11 | 0·52 | 0·74 |
| " -leucine | 0·08 | 0·09 | 0·35 | 0·86 |

We have used the columns to separate various mixtures of dinitrophenyl amino-acids, including a mixture containing dinitrophenyl-glycine, -serine, -alanine, -valine, -leucine and ε-dinitrophenyl-lysine. The order in which the compounds were eluted from the column was confirmed by identifying the eluted bands by use of paper chromatograms. We have also shown that recovery of dinitrophenyl derivatives (estimated spectrophotometrically: λ, 358 mμ) from these columns is substantially quantitative. Dinitrophenyl-serine, for example, was eluted in 96–99 per cent recovery in four replicate experiments. However, dinitrophenyl derivatives of the aromatic amino-acids tyrosine and phenylalanine are not fully eluted from the column, and dinitrophenyl-glycine appears to suffer partial decomposition.

The shape of the concentration peaks in the effluent solution was investigated by taking fractions at frequent intervals and estimating the amino-acid present in each fraction. The peaks were sharp and usually nearly symmetrical; but in certain cases (for example, dinitrophenyl-valine and -leucine) the slope at the front of the peak was rather sharper than that of the rear. Full details of this work will be published elsewhere.

S. M. Partridge
T. Swain
University of Cambridge and
Department of Scientific and Industrial Research,
Low Temperature Station,
Downing Street, Cambridge.
May 24.

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## Treatment of Paper for Chromatography of some Colloidal Electrolytes

The surface of filter paper, in contact with water, has a slight negative charge[1], and this may account for the non-adsorption of certain colloidal electrolytes such as dyes of the 'acid' type, when developed with water, as these also carry a net negative charge in aqueous solution. By the application of principles similar to those described by Weiss[2], a 'primary adsorbate' may be applied to paper, in this case being so arranged that the paper now has a net positive charge in contact with water. A suitable compound for this purpose is cetyl trimethyl ammonium bromide, the paper being soaked in 0·03 per cent aqueous solution and dried before use.

By development with water, mixtures of tartrazine, geranine (I.C.I., Ltd.), eosin and fluorescein have been separated on such paper using the central-feed technique[3], a noteworthy feature being the sharpness of separation and the uniformity of zones, although there is little or no space between them. Similarly, detergents of the anionic type such as sodium stearate and 'Teepol' (Shell Chemicals, Ltd.) may be removed from aqueous solution.

The location of such colourless adsorbates is conveniently demonstrated by brushing a streak of dilute solution of a weakly adsorbed dye such as tartrazine from the centre of the paper outwards during development. The 'secondary adsorbate' such as 'Teepol' has a net negative charge and does not adsorb the tartrazine, whereas the unaffected area holds it, resulting in a break in the streak. Adsorbates may be eluted by solutions of more strongly adsorbed substances, such as sodium hydroxide.

The above principles have been utilized in the detection of traces of fluorescein used in locating faults in drainage systems; identification of amounts as small as one part in ten million parts of water is somewhat uncertain by viewing directly under ultra-violet light, whereas by allowing approximately 0·1 ml. of such a solution to feed up the 'tail' of a treated No. 3 Whatman paper[3], the fluorescein thus concentrated on the 'tail' and centre of the paper, when exposed to ultra-violet light, gives an unmistakable fluorescence.

L. Rutter
Sir John Cass College,
Jewry Street, London, E.C.3.
April 21.

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## Colorimetric Estimation of Silver

In some current work using evaporated metal films, it became necessary to estimate small quantities of silver of about $2 \times 10^{-5}$ gm. The method developed by Schoonover[1] and quoted by Welcher[2], the "B.D.H. Book of Organic Reagents" and others, seemed suitable. Preliminary experiments, however, indicated that the method was unreliable. The purpose of this note is to present some typical results of a subsequent series of experiments which show the unsatisfactory nature of the method.

The measurements given below were made with two silver solutions: (i) An acid solution containing 0·00218 gm. of silver per litre. This was prepared by dissolving spectroscopically pure silver in nitric acid, the concentration of nitric acid in the final solution being about 0·016 *N*. (ii) A neutral solution of silver nitrate containing 0·00214 gm. of silver per litre which was prepared from A.R. silver nitrate. The colour reagent, *p*-dimethylaminobenzalrhodanine, was recrystallized twice from ethyl alcohol, and a 0·02 per cent solution in ethyl alcohol used.

The procedure outlined by Schoonover[1] was adopted, the apparatus used throughout being of borosilicate glass. To each of a series of five graduated tubes 0·5 ml. of 4 *N* nitric acid and amounts of the silver solution, increasing by 1 ml. in successive tubes, were added, the volumes made up to 15 ml. and the solutions thoroughly mixed by shaking; 0·5 ml. of the reagent was added to each tube, the solutions again mixed and allowed to stand for 30 min. The central tube was taken as a standard: for example, in a typical experiment in which the tubes contained 9, 10, 11, 12 and 13 ml. respectively of the silver solution, that in the third tube containing 11 ml. was used as the standard and the other solutions compared with it using a plunger-type optical colorimeter.

Typical results are shown in Fig. 1, in which the true concentration of silver is plotted against the apparent concentration. The latter is obtained as the product of the true concentration of the standard and the depth ratio measured on the colorimeter. Measurements have been made, using both silver solutions, with tubes containing 0·5–2 p.p.m. of

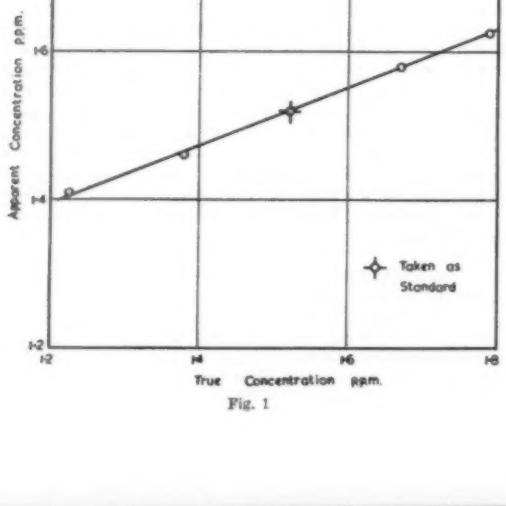


Fig. 1

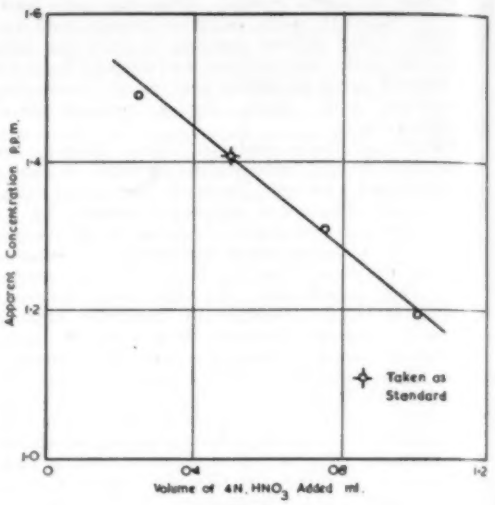


Fig. 2

silver, the concentrations in the tubes of each set being within ± 0·3 p.p.m. of that adopted as the standard. The results are of the same general character as those in Fig. 1, namely, that concentrations less than the standard are over-estimated and those greater than the standard are under-estimated. Both of us have made measurements on the same and on completely different sets of solutions with very similar results. In addition, solutions of the rhodanine reagent from two different sources have been used with no apparent difference.

The original paper by Schoonover directs attention to the importance of the order of addition and concentration of the nitric acid. Addition of the nitric acid after the reagent is said to produce a yellow precipitate. This has not been found in the range of concentrations used. Apart from stating that the concentration of the nitric acid is important, Schoonover gives no quantitative indication of the effect this has. In the present investigation measurements have been made with solutions containing the same amounts of silver and different amounts of 4 *N* nitric acid. The results of a typical experiment, in which the true concentration of silver was 1·4 p.p.m., are shown in Fig. 2. The standard used for the comparison contained 0·5 ml. of 4 *N* nitric acid.

In the seventh and subsequent editions of the "B.D.H. Book of Organic Reagents", the use of 1 gm. of ammonium acetate in place of nitric acid is suggested. This is, however, unsatisfactory because its use with neutral silver solutions results in the formation of a fine red precipitate visible to the eye and suspended in a yellow solution. These solutions, when viewed through the colorimeter, appear yellow in contrast with the pink-red colours obtained if 0·5 ml. of 4 *N* nitric acid is used. No satisfactory quantitative results using this modification of the method have been obtained.

The unreliability of the method is most likely to be attributed to the fact that the red silver complex does not form a true solution, and consequently the depth of colour obtained will be a function of both the amount and the state of dispersion of the silver-rhodanine complex. The results illustrated in Fig. 1 are readily explicable if, as seems reasonable, the

size of the complex particles increases with increasing silver concentration. The size of the particles would also be expected to increase with increasing concentration of other ions present; such a mechanism readily explains the results illustrated in Fig. 2. In addition, ammonium acetate in the comparatively high concentration used should be efficient in causing the aggregation of the particles; the appearance of a fine red precipitate in the presence of ammonium acetate is clear evidence that this is the case.

That the silver-rhodanine complex does not form a true solution was, in fact, realized by Schoonover. It must be concluded that the method, either in its initial or modified forms, is unsatisfactory for quantitative work.

J. A. Allen
D. G. Holloway

H. H. Wills Physical Laboratory,
University of Bristol. April 20.

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## Evaporation and Mobility of Naphthalene Molecules

The rates of evaporation, into a vacuum, of solid naphthalene from different crystal faces have been measured directly. Two crystals of naphthalene, masked so as to leave exposed only portions of the faces under study, were mounted so that evaporation from the exposed portions produced a torque which was measured with a quartz suspension fibre. It has been found that both the absolute rates of evaporation and their temperature coefficients are different for different faces, indicating variations in condensation coefficients and energies.

Certain anomalies appeared in the results, which suggested that naphthalene molecules might be mobile over the surfaces of the solid phase and of the glass supports. This was studied, by the following technique, before continuing with the exact measurement of evaporation rates.

A spot of solid naphthalene was placed at the centre of a thin glass disk (microscope cover-slip, 20 mm. diam.). Over this was clipped a thin glass hemisphere, about 7 mm. in diameter, the edge of which was ground flat so that it rested in close contact with the surface of the disk. If lateral mobility on glass occurred, molecules of naphthalene would travel radially outwards from the periphery of the hemisphere for some distance prior to evaporating off the surface of the disk when the assembly was placed in a vacuum. Two such assemblies were mounted, facing in opposite directions, to produce a torque when evaporation took place. Measurements of the torque would give a measure of the total number of molecules emitted irrespective of distance travelled on the surface, since radial migration was symmetrical about the centre of the assembly. One half of the periphery aperture (that facing towards the axis of suspension) was then closed and the torque again measured. Now, since any surface migration was directed away from the axis of suspension, the moment was increased by a simple multiple of the mean distance travelled by a molecule before evaporation. By difference, the mean distance of travel was obtained. The aperture between hemispheres and disks was of dimensions such that the torques measured were ascribable to mobile molecules; interference by gas-phase molecules streaming out was negligible.

Similar measurements were made using other substrates. In each case it was found that the plot of the logarithm of the torque measured against the reciprocal of the temperature yielded a straight line. Equations of the form $\log_{10}F = A - B/T$ (where $F$ is force in dynes per mm. of periphery of hemisphere, $T$ is temperature in °K, $A$ and $B$ are constants) were fitted by the method of least squares. From $B$ an energy in kcal. per gram mole was calculated. Typical values, some with repeat determinations, with various substrata were:

| Substratum | $A$ (arbitrary units) | $E$ (kcal.) |
|---|---|---|
| Mica (freshly cleaved) | 5·60; 5·80 | 13·1; 13·3 |
| Tin (foil, washed with solvents) | 8·33 | 14·2 |
| Graphite (oriented) | 7·33; 7·50 | 15·3; 15·2 |
| Glass (washed with solvents) | 7·11 | 15·0 |
| Glass (as manufactured) | 7·81 | 15·7 |
| Glass (greasy) | 7·93; 8·09; 8·10 | 16·2; 16·2; 16·2 |

The estimation of the mean distance travelled along the solid surface, involving a difference calculation, was not very accurate. However, it was found to be of the order of 1 mm. on glass and 3 mm. on graphite. Further work is being done in the hope of obtaining more accurate data.

It is clear that surface mobility does exist, and that the energies of translation and desorption may be obtained from the observations obtained by this technique. A full description of the work and the calculations will be published elsewhere.

I am indebted to Dr. F. J. Wilkins and Prof. E. K. Rideal for advice and encouragement, and to the Chief Scientist, Ministry of Supply, for permission to publish this work.

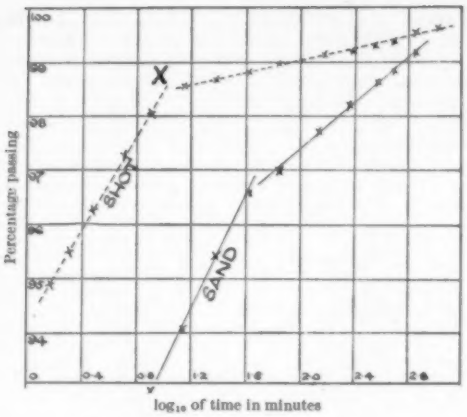
V. J. Clancey

Davy Faraday Laboratory,
Royal Institution,
London, W.1.
June 1.

## Size-Frequency Distributions

In the determination of the size-frequency distribution of a particulate material by sieve analysis, it is often assumed[1] that the rate of sieving is proportional to the quantity of material on the sieve. If $y$ is the amount of material of size smaller than the sieve mesh at any time $t$, this assumption leads to the equation $y/y_0 = \exp(-at)$, where $a$ is a constant, and $y_0$ is the value of $y$ at $t = 0$. In practice, the equation $y = at^{-m} + b$ (equat. 1) has been found to apply[2].

During the course of some experiments on the variation of the statistical parameters in eroded, naturally occurring, granular material, subsidiary experiments were performed to determine the approximate time of sieving necessary to give the amount of any particular size to about 0·5 per cent. The material used was a quantity of washed river sand which had previously passed a No. 7 B.S.S. sieve, and the time-quantity relation was of the form given by equation 1. To an extended scale, however, the relation takes the form shown in the accompanying graph, where two linear relations of the form $y_0 - y = a \log t + c$ are evident. The results from a repetition of the experiment, with the same quantity (100 gm.) of lead shot, show an even more marked transition point ($X$). It has not yet been possible to extend the investigation to other




materials, or to suggest an explanation for the abrupt changes in the quantity-logarithmic time curves.

J. K. Alderman
Basil Standing

Whitworth Engineering Laboratories,
University, Manchester 13.
March 1.

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## Runs Up and Down on a Lattice

$N$ different numbers arranged at random in a sequence can be considered to be consisting of $k$ groups of numbers alternately in ascending and descending order. Groups of numbers in ascending and descending order are called runs up and down respectively. Kermack and McKendrick[1], Levene and Wolfowitz[2] and others have dealt with the theory of runs up and down. Recently[3], I developed independently a method similar to that of Fréchet[4] for calculating the factorial moments of a large number of distributions considered in the statistical literature. This method is directly applicable for calculating the factorial and product moments of the distributions arising in the theory of runs up and down. Thus, for example, the second factorial moment for the distribution of the total number of runs of length $p$, or of $p$ and more, is the sum of the expectations of the different configurations giving two such runs. The expectation for each of the configurations is the product of their probability and the number of configurations that can be had from the $N$ numbers. The probability for any of the configurations can be evaluated step by step by breaking it into two independent sections and expressing it as the sum of two new configurations as illustrated below.

Let $A$ represent the configuration for which the probability is to be determined.

$A$ consists of two runs of length $p$ formed from $2p$ numbers.

The probability for the above configuration is the product of the probabilities for two separate ascending runs each of length $p$ minus the probability of an ascending run of length $2p$

$$= \left\{ \frac{1}{p!\,p!} - \frac{1}{(2p)!} \right\}.$$

Similarly, the product of the probabilities for runs of length $(p-1)$ and $(q-1)$ is the sum of the probabilities for the configurations $B$ and $C$ noted below:

From the above relation, it can be shown that the probability for $B$ is $1/(p+q-2)\,.\,(p-2)\,!\,(q-1)\,!$

Using the above method, the expectation and the variance for the total number of peaks and troughs[5], or the number of runs up and down, along the $n$ axes for $\prod_1^n l_r$ different numbers distributed in the form of an $n$-dimensional lattice of side $l_1, l_2, \ldots l_n$ have been calculated, and are given below:

$$\text{Expected No. of troughs and peaks} = \frac{2}{3}\left\{ n(1^n) - 2(1^{n-1}) \right\}, \quad (1)$$

$$\text{Expected No. of runs up and down} = \frac{1}{3}\left\{ 2n(1^n) - (1^{n-1}) \right\}, \quad (2)$$

$$\text{Variance for (1) and (2)} = \frac{1}{90}\left\{ 16n(1^n) - 29(1^{n-i}) \right\}, \quad (3)$$

where $(1^n)$ denotes the monomial symmetric function of degree $r$ in $l_1, l_2, \ldots l_n$. For $n = 1$, (3) reduces to the expression given by Kendall[5].

The higher cumulants are linear expressions in $(1^n)$, $(1^{n-1})$, . . . , and therefore the distribution approaches the normal form when $l_1, l_2, \ldots l_n \to \infty$.

Full details will be published in the *Journal of the Indian Society of Agricultural Statistics*.

P. V. Krishna Iyer

Indian Council of Agricultural Research,
New Delhi.
April 8.

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## Mineralogical Composition of Quaternary Swedish Clays

The general opinion was that the quaternary, that is, glacial and postglacial, clays of Sweden consist mainly of physical weathering products from the ice age. During this age, the moving glaciers attacked the top of the rocks (mainly granite, gneiss and similar materials) and ground them into particles of various size: boulders, stones, gravel, sand, silt and clay. As a result of transportation by ice and glacial rivers and subsequent deposition, the different quaternary formations were formed, the clays being deposited in the sea. It was therefore logical to regard the clay fraction as rock 'flour', built up of primary minerals, typical for the original rocks but more or less chemically weathered. The micas were assumed to be responsible for the high plasticity of the clays. However, doubts arose later as to the correctness of the

opinion that the clays are built essentially from primary minerals.

During a stay at the University of Illinois, Urbana, Ill., during 1947–48, I had the opportunity of examining some Swedish soils by the differential thermal method, and to some extent with X-rays. The investigations included: (*a*) a series of soil profiles from Marsta, Uppland, consisting of glacial and postglacial soils from different elevations and in different hydrological conditions, (*b*) glacial and postglacial subsoils from various parts of Sweden from the northern to the southernmost part of the country, and finally (*c*) two till clays from Scania.

The soils to be examined were freed from organic matter and carbonate by mild treatment with hydrogen peroxide and hydrochloric acid. Thermal curves were run on the fractions of less than 2 $\mu$ and in some cases also on the fractions less than 0·2 mm. To check the results from the thermal analysis some of the samples were submitted to X-rays and some analysed for non-replaceable potassium. The behaviour of these soils upon the addition of benzidine was also examined.

From the analyses it appeared that the major mineral constituent of the clay fraction is illite. Montmorillonite in amounts detectable with the thermal method was not found. This applies also to kaolinite, except for one of the till clays, where the kaolinite probably originates from the prequaternary kaolin deposit in north-eastern Scania. The content of primary minerals seems to be small. Quartz is common, the amount in the glacial and till clay fractions, however, being too small to show up on the thermal curve. The content of calcium carbonate varies from zero for most of the postglacial soils up to 29 per cent for one of the glacial subsoils.

Considering the fact that the soils represent areas with fairly large differences in climate and that they originate, to some extent, from different parent materials, it is of interest to note the great similarity so far as the clay mineral composition is concerned. A slight difference between the glacial and postglacial clays from the soil profile series could be established, namely, a higher content of illite but a lower content of quartz in the glacial than in the postglacial soil clays. This may be explained as a result of the erosion of the glacial clay and its subsequent redeposition as postglacial clay, whereby an enrichment of quartz but a loss of the small illite particles may have taken place.

In general, benzidine colours montmorillonite blue, whereas micas, kaolin, felspars and quartz are inert. The Fithian illite gives an intense blue coloration. It is noteworthy that some of the clays, though treated in the same way and in all cases containing illite, gave an intense blue colour, whereas other samples became pale blue or pale green to yellow-green. This indicates that illite may respond in different ways to benzidine, probably as a result of differences in composition and in particle size.

The investigation has given evidence that the clay mineral illite is the major constituent of the clay fraction, and that the primary minerals do not play such an important part as they have often been supposed to do. It is therefore not justifiable to regard the quaternary clays as glacial rock 'flour' from granite, gneiss, etc., which would imply the presence of mainly primary minerals. In this connexion an interesting question arises, namely, the origin of the illite. The illite may be of pre-quaternary origin, or it may have been formed entirely or partly from the glacial erosion materials by chemical weathering. This must, however, be left as an open question at the present.

A more detailed report of the investigation will be given in Swedish elsewhere.

I am indebted to Dr. Ralph Grim, Illinois State Geological Survey, and to Dr. George Clark, Chemistry Department, University of Illinois, Urbana, Ill., for supplying the equipment necessary for the thermal analysis and the X-ray work respectively.

LAMBERT WIKLANDER

Institute of Pedology,
Royal Agricultural College,
Uppsala.
April 14.

## Earlier Records of *Elminius modestus* Darwin in British Waters

THE Australasian barnacle *Elminius modestus* Darwin was first recorded by Bishop[1] as occurring in very large numbers on the Admiralty Raft moored in the mouth of Chichester Harbour, in July 1945. Crisp and Chipperfield[2] recorded the species from the Essex coast in October of the same year. Both authors extended the area of distribution with records made in 1946–47. From the distance apart of the earliest two published records it would appear that *E. modestus* was already well established in the summer of 1945.

Recently, I had occasion to re-examine collections made in 1944 of fouling organisms from ships. Numerous *E. modestus* were found in collections made in August of that year from a ship that had undocked in the preceding March. This ship had plied exclusively between the Isle of Wight and the Normandy coast, with short periods at anchor at Spithead and two separate weeks in Portsmouth Harbour and Southampton respectively. There is no question, therefore, that these *E. modestus* were bred in this section of the Channel, and little doubt that they settled during periods when the ship was at anchor in English waters. The large numbers of adults found presupposes a plentiful supply of cyprids from a well-established stock of adults. Uncrowded specimens averaged 4·5 mm. in carinorostral diameter, the largest being 6 mm. across.

Several recently metamorphosed specimens were taken on July 6, 1944, from a panel exposed at the head of the Emsworth Channel, Chichester Harbour, for less than three weeks.

Further examination of the collections has revealed two adult specimens 8·5 mm. × 6·5 mm. removed from a boom defence vessel at Portsmouth early in May 1944. This vessel had not left the vicinity of Portsmouth during the preceding fourteen months since undocking in February 1943. It is unlikely that these specimens could have reached this large size between the beginning of the breeding season in mid-March and the end of April 1944. Specimens collected by Bishop in July, when growth is more rapid, only reached 6 mm. in a similar period. Furthermore, the largest specimens from test panels immersed for four weeks in June–July 1948, and thus of maximum age four weeks, averaged 4–5 mm. in greatest diameter. This growth-rate agrees reasonably well with that recorded by Bishop in 1945 for the same season and locality. The indication is, therefore, that these large Portsmouth specimens belonged to a 1943 settlement in the Portsmouth area. They could

have settled any time between March and September or early October of that year.

The average size of adult specimens from Chichester Harbour during the period 1945–49, 5–6 mm., agrees well with that recorded for Australian[3] and New Zealand[4] specimens, and this size in Chichester Harbour is reached apparently in about two months in the summer. The maximum size so far recorded, 9 mm., is well below the 12·5–13 mm. recorded for these areas. In July, the surface-water temperature in Chichester Harbour may reach 21° C. for a short time only, comparing favourably with the published average figure of 24° C. for January in parts of Sydney Harbour. As, however, winter temperatures drop to 6–7° C. or lower, compared with 15° C. in Sydney Harbour, and average temperatures for all seasons are lower, this may account for the failure of the species to reach the upper limit of size recorded for Australian and New Zealand specimens.

In conclusion, it appears that *E. modestus* was fairly common in the Portsmouth–Isle of Wight area in the summer of 1944 and that the species was already established in 1943, though to what extent is unknown. Growth of the species in British waters is probably limited by the lower water temperature compared with that of the original habitat.

H. G. Stubbings

Royal Naval Scientific Service.
April 14.

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## Extension and Radial Growth in Trees

Chowdhury and Tandan[1] report that, in certain Indian woody species, radial growth does not commence until the first period of extension growth has ceased, and they contrast this behaviour with that in European and North American species, where both extension and radial growth normally proceed simultaneously, and in which an obligate dependence of radial on extension growth is generally held[2] to occur in both diffuse-porous and ring-porous types. The results of recent experiments of mine, however, indicate that some modification of this generally accepted view is necessary so far as the initiation of radial growth in ring-porous European species is concerned.

As Priestley and Scott[3] have shown, whereas in diffuse-porous trees the resumption of radial growth in the trunk progresses basipetally from the expanding buds comparatively slowly, so that there may be a considerable delay between the initiation of radial growth in the twigs and that in the base of the trunk, in ring-porous trees there is a rapid resumption of secondary growth throughout the trunk at an early stage of development of the buds. Indeed, the initiation of cambial activity in such trees, for example, *Fraxinus excelsior*, has been reported[4,5] actually to precede swelling of the buds; but nevertheless Priestley[3] maintained that even in *Fraxinus excelsior* there is an obligate connexion between cambial activity and bursting of the buds. The crucial experiment of testing the effect of debudding on cambial activity in *Fraxinus excelsior* does not appear to have been previously carried out, although this was done for larch by Th. Hartig[6] many years ago, and it was found that secondary growth occurred in the trunk, even in debudded trees.

Three ten- to twelve-year old trees of ash were decapitated on April 3 at 10 ft. above the ground, and all branches and buds were removed from the trunks. (All adventitious buds which appeared later were similarly removed.) At this date there was no sign of renewal of secondary growth and there was no indication of swelling of the buds. Observations on the cambium were made at intervals of seven to ten days by removing small blocks and sectioning. Similar observations were carried out on intact trees of comparable age. By April 27 a well-developed ring of wide vessels had been formed in both decapitated and normal trees. Further secondary growth occurred in both series at an equal rate up to May 15; but by the end of May the width of the new annual ring in the decapitated specimens was falling behind that of the normal trees. Thus in *Fraxinus excelsior* the initiation of cambial activity can occur in the trunks even in the absence of buds.

In a further experiment, the buds were removed individually from three- to four-year old trees of ash on March 30; but the twigs themselves were allowed to remain. In these trees wide-vessel formation afterwards occurred throughout the plant; it was greatest at the base of the main stem, and was restricted in the twigs to a few isolated small vessels. The direction of this gradient in cambial activity not only provides strong evidence against the possibility of some 'influence' having travelled from the buds in a basipetal direction before debudding had been carried out, but also precludes the possibility that the renewal of cambial activity was a wound reaction resulting from the debudding operation. Similar results were obtained with seven-year debudded trees of *Quercus robur*. In comparable experiments with the diffuse-porous types, *Acer pseudoplatanus* and *Tilia europæa*, however, no signs of cambial activity wsre obtained in decapitated or debudded trees.

These results would seem to indicate a fundamental difference between ring-porous and diffuse-porous types of temperate regions with regard to the *initiation* of cambial activity, which is apparently dependent upon extension growth in the latter, but not in the trunks of ring-porous trees. Normal vessel development is, however, very restricted in the tips of the branches in debudded ring-porous trees and appears normally to be dependent mainly upon extension growth. In view of the demonstration that renewal of cambial activity in woody species can be stimulated by the application of auxin[7,8], it appears that whereas in diffuse-porous types the cambium is entirely dependent upon an exogenous supply of auxin from the extending shoot[9], in ring-porous types another source of auxin is available in the initial stages of secondary growth.

P. F. Wareing

Botany Department,
Bedford College,
London, N.W.1.
June 9.

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# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT CHEMIST in the Fuels and Lubricants Section of the Central Laboratory, Chiswick—The Staff Officer (F/EV.138), London Transport Executive, 55 Broadway, London, S.W.1 (August 19).

ASSISTANT MASTERS (5, with the necessary qualifications in mathematics, physics or engineering—electrical or mechanical), at H.M. Dockyard Schools—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 3210 (August 19).

CORDET AND HENRY WOODALL SCHOLARSHIP IN GAS ENGINEERING—The Registrar, The University, Leeds 2 (August 19).

LECTURER IN THE DEPARTMENT OF ENGINEERING, County Technical College, Wednesbury—The Director of Education, Department F.E., County Education Offices, Stafford (August 19).

LECTURERS (2) IN MECHANICAL ENGINEERING, a LECTURER IN ELECTRICAL ENGINEERING, and a LECTURER IN CHEMISTRY, at Coventry Technical College—The Director of Education, Council House, Coventry (August 19).

SENIOR HOSPITAL PHYSICIST at the Radiotherapy Centre—The Secretary, United Birmingham Hospitals, Queen Elizabeth Hospital, Birmingham (August 19).

WILLIAM CARTWRIGHT HOLMES SCHOLARSHIP IN GAS ENGINEERING—The Registrar, The University, Leeds 2 (August 19).

DIRECTOR OF IRRIGATION RESEARCH, Punjab—The Office of the High Commissioner for Pakistan, 35 Lowndes Square, London, S.W.1 (August 21).

SENIOR PHYSICIST or ENGINEER, Physics Division, Dominion Physical Laboratory (Concrete Research), Wellington—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (August 21).

RESEARCH ASSISTANT (with a first-class or good second-class honours degree in chemistry) to undertake work in the Coal Constitution Laboratories of the Department of Mining, as part of a small team investigating the chemical constitution of coal—Prof. S. G. Ward, The University, Edgbaston, Birmingham 15 (August 24).

PHYSICISTS and ELECTRONIC ENGINEERS (Experimental Officer grade, unestablished) at Ministry of Supply Research and Development Establishments in and near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.214/50A (August 26).

PHYSICISTS and ELECTRONIC ENGINEERS (Principal Scientific Officer grade, unestablished) at (1) Ministry of Supply London headquarters, (2 and 3) at the Royal Aircraft Establishment, Farnborough: (1) PHYSICIST or ELECTRICAL ENGINEER for co-ordination, guidance and control of research and development in (*a*) radio components, etc., (*b*) radio navigation and radar, etc., or (*c*) radio communications, etc.; (2) PHYSICIST for work on radar display, digital and analogue computers, and radio and line communications equipment, (3) PHYSICIST for research and development in connexion with electronic valves and cathode ray tubes—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.215/50A (August 26).

SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS at the National Physical Laboratory for work on (*a*) ultrasonics, (*b*) acoustics—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.217/50A (August 30).

RESEARCH OFFICER in the Division of Industrial Chemistry, Chemical Engineering Section of the C.S.I.R.O., at Fishermen's Bend, Melbourne, to investigate the mechanism of adsorption of solutes from aqueous solutions on activated carbons and other adsorbents in the presence of co-adsorbates introduced to enhance specificity, and to apply the results in a new continuous industrial chromatographic process—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 2945 (September 2).

DIRECTOR OF HORTICULTURAL RESEARCH, Department of Agriculture for Scotland—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting G.211/50A (September 25).

CHALLIS CHAIR OF CIVIL ENGINEERING at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Sydney, September 30).

LECTURER IN BIOCHEMISTRY at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Sydney, September 30).

ASSISTANT METEOROLOGIST (Radio Sonde) to take operational charge of a radio sonde rawind station at Lagos—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27118/5.

DEMONSTRATOR IN HORTICULTURE, and a DEMONSTRATOR IN BOTANY, at the School of Agriculture, Sutton Bonington—The Registrar, The University, Nottingham.

ENTOMOLOGIST, Desert Locust Survey, under the East Africa High Commission at Nairobi—The Under-Secretary of State, Colonial Office, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

PHYSICIST with research experience in the more classical parts of physics (applied mechanics, properties of matters, etc.), for work in the Spinning Department—The Director of Research, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester 20.

RESEARCH OFFICER IN THE FISHERIES RESEARCH LABORATORY, Jinja, Uganda—The Under-Secretary of State, Colonial Office (Research Department), Sanctuary Buildings, Great Smith Street, London, S.W.1.

SCIENTIFIC OFFICER (Entomologist) for the International Red Locust Control Service, Abercorn, Northern Rhodesia—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M/N/26610/3A.

SENIOR and a JUNIOR GRADUATE PHYSICAL CHEMIST—Dr. F. D. Richardson, Nuffield Research Group in Extraction Metallurgy, Imperial College of Science and Technology, South Kensington, London, S.W.7.

TECHNICAL SECRETARY AND EDITOR (graduate in science)—The Hon. Secretary (A), Society of Glass Technology, Elmfield, Northumberland Road, Sheffield 10.

# REPORTS and other PUBLICATIONS

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